SNOWTERM: A THESAURUS ON SNOW AND ICE
HIERARCHICAL AND ALPHABETICAL LISTINGS

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hierarchical and alphabetical listings

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Abstract
SnowTerm is the result of an ongoing work on a structured reference multilingual scientific and technical vocabulary covering the terminology of a specific knowledge domain like the polar and the mountain environment. The terminological system contains around 3,700 terms and it is arranged according to the EARTh thesaurus semantic model. It is foreseen an updated and expanded version of this system.

1. Introduction
The use, management and diffusion of information is changing very quickly in the environmental domain, due also to the increased use of Internet, which has resulted in people having at their disposition a large sphere of information and has subsequently increased the need for multilingualism.

To exploit the interchange of data, it is necessary to overcome problems of interoperability that exist at both the semantic and technological level and by improving our understanding of the semantics of the data. This can be achieved only by using a controlled and shared language.

After a research on the internet, several glossaries related to polar and mountain environment were found, written mainly in English. Typically these glossaries -with a few exceptions- are not structured and are presented as flat lists containing one or more definitions.

The occurrence of multiple definitions might contribute to increase the semantic ambiguity, leaving up to the user the decision about the preferred meaning of a term. On the contrary, providing a structure to the lexicon so that each term is placed within a semantic network allows to specify its meaning.

The preliminary results of this work of selection and classification of terms on polar and mountain environment are presented here, as a proposal of controlled and structured language with the goal to develop a prototype of a thesaurus on this specific sector.

The thematic areas, covered at present, deal with snow and ice physics, snow and ice morphology, snow and ice radiometry, remote sensing and GIS in cryosphere environment, sea ice, avalanches, glaciers, disaster management and risk prevention.

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³ ARPAV, Arabba Avalanche Centre – http://www.arpa.veneto.it/indice.asp?l=csvdi/w_csvdi/menuit.htm  – mvalt@arpa.veneto.it – 0436 755741
2. Identification of terminological sources and selection of terms

The first sources used to collect the terminology consist of the “Glossario dei termini usati nei bollettini nivometeorologici” by AINEVA and by Friuli-Venezia Giulia Region, the “Sea Ice Glossary” of the Scientific Committee on Antarctic Research-SCAR, the USGS “Glossary of Selected Glacier and Related Terminology”, the “Sea Ice Nomenclature” (Merenkulkulaitoksen julkaisuja 5/2002), the trilingual “Glossary on snow and avalanches” by the Working Group on Avalanches Warning Services of the Swiss Federal Institute for Snow and Avalanche Research, the “Večjezični Slovar - Sneg in plazovi” developed by Pavle Šegula. Additional sources were added later on.

The terminology of these sources was analysed with respect to the degree of semantic relevance in the field. Terms too generic or considered as non pertinent were excluded. Groups of terms that could be collected in specific appendixes were also excluded.

At present the database contains 3,700 records; more than 1,200 non-descriptors have been identified and assigned.

3. Classification of terms

The classification and relational structure is based on the EARTh (Environmental Applications Reference Thesaurus) semantic model.

The terms are arranged according to a classification scheme which is founded on categories. At the first level, the system is structured into categories defined as “ENTITIES”, “ATTRIBUTES”, “DYNAMIC ASPECTS” and “DIMENSIONS”. The “ENTITIES” describe material and immaterial objects; the “ATTRIBUTES” define the nature of the objects, at least as far as their static aspects are concerned; “DYNAMIC ASPECTS” define the activities, the processes and the conditions in which they are involved; the “DIMENSIONS” identify the spatio-temporal circumstances in which all this occurs.

The system is then organized in a framework of different levels and classification knots, and it comprises hierarchical relations. It continues into further levels as they obtain a greater specificity in order to allow a rational arrangement of objects.

The vertical structure can be used as a semantic reference system, stable and partially independent from the context.

The model envisages the possibility of complementing the faceted structure with a system of themes which by crossing with the vertical structure would form a matrix system.

In a thematic approach, the terms linked to a specific sector, are reassembled, while the facet structure tends to scatter them under the more general referral concept.

Moreover, the system of themes, as it was conceived, should be developed by a user according to the specific needs of the applicative context.

One example of thematic setup is provided by the classification into sectors contained in the “Sea Ice Nomenclature” where the terms are clustered according to “ice development”, “sky and air indications”, “ice arrangement”, “terms relating to surface shipping”, “terms relating to submarine navigation”.

4. Software details

All the terms are stored into Firebird, an open source, client-server, SQL database. In order to handle properly the terminological database the SuperThes software (Batschi, 2002) was adopted. It is a tool for thesaurus management developed with the scientific supervision of EKOLab, in the frame of an international cooperation. The web interface will allow to access the system through the internet.

5. Multilingualism

Multilingualism is not the main interest of our working group. Nevertheless, in order not to waste important resources, the already available translations have been collected. The system now contains (including synonyms) 3,200 English terms, the other language are Italian (3,024), Estonian, Finnish, Russian and Swedish (94), French (1,970), German (1,770), Slovenian (1,300) and Spanish (1,870). The enlargement of the number of linguistic equivalents in French and German is mandatory due to the geographical and political position of the alpine area. Other languages will be updated following a direct interest and willingness to cooperate by other institutions.
Fig. 2 - Two screenshots of the tabular window
6. Results, their use and future development

The results of this work is the production of a monolingual terminological system organized both in vertical way -according to a classification system based on categories- and horizontally on the basis of the systems of themes.

SnowTerm could be considered as one of the first attempt to develop a thesaurus on Snow, Ice and Mountain Environment domain.

In order to ensure a better and updated conceptual and terminological coverage, an extension and revision of the system is foreseen. Any other reliable glossary or term list will be considered as potential additional sources.

The semantic structure of the system will also be strengthened. In order to increase the efficiency of the system in information retrieval operations, a set of associative and equivalence relations will be implemented.

The organization of knowledge -through the support of a thesaurus- could bring a strong contribution to the management of the information in the specific domain: by suggesting a language that different institutions could share; ensuring a higher semantic transparency to terminology; providing tools for indexing and retrieving the information and to interchange of data and suggesting semantic maps usable for the conceptual description of the domain.

Bibliographic References


Fugmann R., 1993 - Subject Analysis and Indexing. INDEKS Verlag, Francoforte.


World Meteorological Organization, 2002 - *WMO SEA-ICE NOMENCLATURE*. WMO/OMM/BMO - No.259
Hierarchical Listing
soluble properties in ice sheet
specific gravity
specific snow weight
specific heat capacity of ice
static friction
surface roughness
smooth surface
undulated
temperature
average at 1000m and 2000m
glacier temperature
glacier temperature at depth
glacier temperature near surface
ice sheet temperature
ice sheet temperature near surface
measured ice sheet temperature
ice shelf temperature
ice stream temperature
maximum (temperature)
minimum (temperature)
temperate glacier temperature
tidewater glacier viscosity
till porosity
wind force
dimensions
space
time
balance year
interval
measurement year
season
autumn
spring
summer
winter
dynamic aspects
activities
<physical operations>
<disposal and restoration>
<manipulation, production, consumption>
clear cutting
clearing and grubbing
discharge above the snow surface
firing
projectile firing
forest clearing
intervention
reforestation
regeneration (forest)
ultrasonic logging
- cement grouting
- helicopter transport
- orientation mark
- practical snow stability tests (skiers)
- release an avalanche through test skiing
- rescue
  - air rescue
  - artificial respiration
  - body recovery
  - companion rescue
  - crevasse rescue
  - digging out
  - hasty search
  - heart massage
  - helicopter drop
  - immediate aid
  - improvised search
  - locating
    - close range location rescue beacon (RB)
    - long range search (rescue beacon)
  - organized rescue
  - organized rescue operation
  - probe
    - coarse probing
    - fine probing
    - probing with improvised equipment
  - radio-link
  - rescue (victim alive)
  - rescue of living victim
  - respiration mouth to mouth
  - revival
  - revival attempts
  - search of buried victim
  - self-belay
  - self-help
  - self-rescue
  - warning
- trigger an avalanche

-p <policy activities>
  - avalanche classification
  - avalanche course
  - avalanche rescue organisation
  - classification of glaciers
  - closure
  - effective protective measures
  - evacuation
  - issuing of avalanche warning
  - patrolling of ski runs (skipatrol)
  - permanent protective measures
  - planning
prevention
- protective measures against avalanches
- protective measures against gliding snow
- safety procedure
- shut down of operation
- temporary protective measures
- zoning
- <productive sectors>
- <research activities>
  - assessment of avalanche hazard
    - erroneous evaluation
    - qualitative evaluation of avalanche hazard
    - quantitative evaluation of avalanche danger
    - stability evaluation
  - avalanche forecasting
  - cohesion test
  - complete avalanche survey
  - crystal fabrics strength measurement
  - hand test
  - hardness test
  - ice methods of dating
  - ice sheet numerical modelling
  - location of surging glaciers
  - measurement
    - measurement of settlement
    - meltwater measurement
    - meteorological measurements
  - probe test
  - radio-echo sounding ice thickness measurement
  - rutschblock test
  - shovel shear test
  - shovel test
  - ski pole test
  - slide wedge test
  - snow measurements
  - snow pack examination
  - snowpack analysis (profile)
  - snowpit for profile survey
  - soil investigation for foundation
- <social and cultural activities>
  - ascension
  - ascent
    - winter ascent
  - choice of route
  - descent
  - dropping from helicopter
  - exploration
  - high altitude tour
  - hike
    - ski tour
snow to ice transformation
snow-increase
snowpack evolution
softening
strain at failure
strength
strength reduction in a snow layer
stress
  additional stress
  allowable stress
  compressive stress
  driving stress
    ice stream driving stress
  effective stress
  normal strain
  normal stress
  octahedral stress
  plane strain
  principal strain
  principal stress
  shear strain
  shear stress
    basal shear stress
    effective shear stress
  tensile stress
  yield stress
    tidewater glacier yield stress
    yield stress of ice
    yield stress of till
subglacial conveyance
supercooling
superglacial conveyance
surface release
tidewater glacier deformation
turbolent suspension
uplift of glacier surface
water flow of glacier-fed stream
water flow within glacier
  water flow at glacier bed
    water flow over soft bed
    water flow in linked cavities
    water flow in tunnel
  wetting (snow pack)
changes in sea level
atmospheric processes
  Atlantic front
  accretion
  accumulations
  air flow
  anticyclone
- short-wave radiation
- solar radiation
- visible radiation
- regelation
- snow shower
- storm
- snowstorm
- temperature fluctuations
- thermal inversion
- thermal range
- thunder
- thunderbolt
- thunderstorm
- trough
- warm front
- weather
- weather pattern development
- weather with high radiation cooling
- whirl
- wind
- blizzard
- bora
- breeze
- fohn
- gust of wind
- katabatic wind
- sirocco (south west wind)
- surface wind
- whirlwind
- wind aloft
- mechanism of movement
- release mechanism
- <bioecological processes>
- <pathological processes>
- cardiac and circulatory arrest
- chilblains
- hypothermia
- hypothermic
- icing
- frostbite
- lesion
- signs of death
- snow-blindness
- suffocation
- behavioural processes
- biological processes
- acclimatisation
- death
- death by asphyxia
- scent
ecological processes

>cognitive processes>

<physical and chemical processes>
- biochemical processes
- chemical processes
- physical processes
  - avalanche air pressure
  - birefringence
  - buckling
  - change in audio volume
  - cohesion
    - low cohesion
  - compression failure
  - cooling
  - density variation with depth
  - disturbance
  - heat conduction in ice
  - internal friction
  - inversion
  - radiation penetration of snow and ice
  - strain inside snow cover
  - sublimation
  - superimposed pressure
  - velocity variation in time
- physical-chemical processes
  - isotope-temperature relation
    - ice sheet isotope-temperature relation
  - warming up
- shock wave
- sound wave

<processes related to materials and products>
- sections, screwed together

<social, cultural and policy processes>
- distress signal

entities

immaterial entities

<abstract concepts and principles>
- cause of death
- external causes
- feeling for terrain
- internal causes

<knowledge systems>

<form of culture>
- Ice Saints

disciplines
- climatology
- geothermics
- glaciology
- orography
- snow science
technology

<measures>
- UIAA label
- administrative measures
  - blasting licence
  - economic measures
  - legislative measures
  - planning measures
  - rezoning
- preventive measures
- search strategy

<methods and techniques>
- Carbon-14 dating
- cross bracing
- dating of ice
- finite element method
- hard rope
- hydrological method (mass balance)
- interrupted arrangement
- location method
- mass balance measurement methods
- method of direction-finding
- revival methods
- staggered arrangement
- test arrangement

<parameters, criteria and factors>
- criteria
- factors
  - ablation controlling factors
  - accumulation controlling factors
  - altitude factor
  - edge effect force
  - enhancement factor
  - marginal factor
  - safety factor
  - shape factor
  - trigger factor
  - weather factors
- parameters
  - biological parameter
  - chemical parameters
    - Beryllium-10 in ice
    - Deuterium excess
    - Oxygen isotopes in sea water
  - ecological parameter
    - tree line
- general parameter
  - frequency
  - position
  - relative height
- medium temperature
- small
- very big
- very small
- grain shape
- grain size
- height of crown
- height of deposit in compression zone
- ice concentration
- ice cover
- ice impurities concentration
- ice limit
- ice sheet mass balance
- ice sheet rate of thickness change
- ice sheet response to changes
- ice sheet stability
- ice sheet volume
- ice thermal conductivity
- ice thermal diffusivity
- internal snow strength
- layer depth
- length of structure
- limit of a layer
- liquid water content
- mechanism of avalanche
- penetration depth
- ram resistance
- resistance to deformation
- runout distance (avalanche)
- slush limit
- snow average depth at 1600m
- snow height
  - total depth of snow cover
- snow line
- snow load
- snow pressure
- snow–line
  - annual snow line
  - dry snow line
- stretch limit
- subglacial water pressure
- surge period
- temperate glacier impurity content
- thaw time
- thickness of fracture
- thickness of snow cover
- time lag in glacier response
- total depth of recent snow
- velocity
  - average velocity over cross-section
- balance velocity
- flow speed
- friction velocity
- impact speed
- nucleus speed
- percolation speed
- sliding velocity
- strain rate
  - strain rate variation with depth
- submergence velocity
- velocity in extending/compressing flow
- velocity in laminar flow
- velocity in transverse section
- velocity on longitudinal line
- velocity on vertical line
- velocity vertical component
- viscosity coefficient
- water content
  - liquid water content
- water equivalent of snow
- water pressure within glacier
- wet-snow line
- rate of flow
- oceanographic parameter
- parameters related to buildings
  - effective length of structure
  - grate tilt
  - height of grate
  - effective height of the defense structure
- inclination of the supporting plane
- roof shape coefficient
- shape of roof
- space between protective structures
- space between supports
- vertical height of a structure
- width of section
- physical parameter
  - activation energy
    - creep activation energy
    - grain boundary self-diffusion activation energy
    - volume self-diffusion activation energy
  - advection parameter
  - air pressure inside the pores
  - albedo
  - allowable loading
  - angle of friction
  - coefficient of resistance
  - deflecting force
  - deformation
  - degree of loading
lateral structure
massive structures
protecting structures
retaining structures
  avalanche defense structure
  permanent retaining structure
  temporary retaining structure
single structure
staggered structures
supporting structure
arresting wall
avalanche shed
buffer-line
catching dam
defenses against snow creep
deflecting barrier
deflecting structure
deflecting wall
deflection dam
horizontal board fence
  solid snow fence
jet roof
network of avalanche defense structures
protective ramp
reinforcement of potentially endangered buildings
snow rake
snowfences
trench
vertical board fence
wall deflector
wind baffle
wind net
earth terrace for reforestation
free-standing wall
heliport
limit of the construction area
mid station
observation station
  comparative observation station
permanent structures
retarding mound
shelter
slide ramp
top terminal
wall terrace
<materials and products>
<materials and products by properties>
  light metal
materials
  U section
angle iron
channel iron
channel steel
double T beam
hardwood
mortar
rectangular timber
rolled steel
sawn timber
strand
thin section

products
<cultural products>
appraisal
avalanche bulletin (AB)
avanche register
avalanche zone plan
bulletin of the Avalanche Warning Service
chart of snow cover heights
ice sheet map
map
map of avalanche paths
snow and weather bulletin
statement
synoptic chart

<products for the consumption>
alignment ribbon
anchor system
anchor loop
basal anchorage
rock anchor
steel anchor
calorimeter
charge
explosive charge
propulsion charge
crampons
current meter
dud
dynamometer
explosive
freezing mixture
gap
hot water bottle
ice-axe
impact fuse
mortar shell
net of cables
shape charge projectile
side guy
ski track
ski lift track
usual track
variant
equipment and technological systems
equipment
Ambu manual breathing device
GAZEX
active identifying object
akia
avalanche airblast
avalanche brake
avalanche breaker
avalanche cord
avalanche shovel
backstay
ball joint
bazooka
boom for explosive charge
cable
climbing skins
cog railway
cruciform wind-baffle
cutter–blower
deadman
direction finding antenna
down jacket
dummy
electronic transceiver
emergency radio facility
flange
flexible joint
fragmentation shell
full harness
fuse
detonating cord
gas exploder
hammer
igniter
instantaneous igniter
projectile detonator
improvised shovel
loop
magnetometer
measuring cap
minishovel
mortar
outrigger for explosive charge
over–snow vehicle
passive identifying object
patroller
pin
pin joint
pole for explosive charges
post
pressure measuring device
probe
avalanche probe
improvised probe
metal detector
ram penetrometer
pulley
radar
rescue beacon (RB)
double frequency rescue beacon
responder
retarding wedge
rope pulley
safety binding
safety straps
shear-frame
ski crampons
ski pole grip
ski pole probe
ski pole strap
sledge
emergency sledge
explosives sleigh
rescue toboggan
two-ski drag
sledge runner
snow blower
snow cutter
snow lysimeter
snow sampler
snow shoes
snow stake
snowboard
snowcat
snowplough
splitting wedge
string line
support
adjustable support
tail unit
telescopic pole
tension anchor	trestle
warm-air inhaler
warning sign(s)
avalanche slope
closed slope
east slope
east slopes
flank
north side
north slope
north slopes
open slope
reverse slope
scree slope
shady side
slope
- avalanche slope
- concave slope
- convex slope
east slope
foot of a slope
grassy slope
lee slope
north slope
open slope
opposite side slope
shaded slope
slope with accumulation of drifted snow
snow covered slope
south slope
steep slope
- extreme slope
- extreme steep slope
sunny slope
upwind slope
slope in the shade
south side
south slopes
west slope
west slopes
snow barkhan
snow bridge
snow ridge
snow slab
- hard slab
- snow slab on lee slope
- soft slab
wind-slab
snowfield
solid base of snow cover
weak base of snow cover
spur
summit
<ice by concentration>
- bergy water
- close ice
- compact ice
  - consolidated ice
- ice-free
- open ice
- open water
- very close ice
- very open ice

<ice by development stage>
- first-year ice
  - medium first-year ice
  - thick first-year ice
  - thin first-year ice
    - thin first-year ice first stage
    - thin first-year ice second stage
- new ice
  - frazil ice
  - grease ice
  - shuga
  - slush
- nilas
  - dark nilas
  - ice rind
  - light nilas
- old ice
  - multi-year ice
  - second-year ice
- young ice
  - grey ice
  - grey-white ice

<ice by formation>
- ice of land origin
  - calved ice of land origin
    - bergy bit
    - calving
      - iceberg calving
    - growler
    - ice island
  - glacier ice
    - firn ice
    - glacier tongue
    - ice stream
    - ice wall
    - serac ice
- ice under pressure
- ice-bound
- nip
- blue ice
- ice crystals
- ice needle
- nucleus of crystallization
- white-fine bubbly ice
- impurities in ice
  - Carbon dioxide in air bubbles in ice
  - Carbon dioxide in ice
  - Oxygen isotopes in snow and ice
  - dust in ice
  - insoluble impurities in ice sheet
  - methane in ice
  - microparticles in ice
  - nuclear fall-out in ice
  - volcanic deposits in ice
- snow
  - avalanching snow
  - cohesive snow
  - cold snow
  - coloured snow
  - crusty drifted snow
  - deep snow
  - diamond dust
  - drifted snow
  - dry snow
  - early snow
  - felt-like snow
  - fine grained snow
  - firn
    - firn mirror
  - firn snow
  - gliding snow
  - granular snow
  - hard snow
  - loose snow
  - melting snow
  - moist snow
  - new snow
  - old snow
    - old snow with facet(t)ed grains
    - old snow with rounded grains
  - perennial snow
  - powder snow
  - prism (crystal)
  - recent (new) snow
  - rotten snow
  - settled snow
slush
snow crystals
<classification internazionale della neve stagionale al suolo 200
  decomposing and fragmented precipitation particles
    partly decomposed particles
    wind broken particles
  depth hoar
    chains of depth hoar
    hollow cups
    hollow prisms
    large striated crystals
    rounding depth hoar
  faceted crystals
    near surface faceted particles
    rounding faceted particles
    solid faceted particles
  ice formations
    basal ice
    ice column
    ice layer
    rain crust
    sun crust
  machine made snow
    crushed ice particles
    round polycrystalline particles
  melt forms
    clustered rounded grains
    melt-freeze crust
    rounded polycrystals
    slush
  precipitation particles
    columns
    graupel
    hail
    ice pellets
    irregular crystals
    needles
    plates
    rime
      hard rime
      soft rime
    spatial dendrite
    stellar & dendrites
  rounded grains
    compattate dal vento
    faceted rounded particles
    large rounded particles
    small rounded particles
  surface hoar
    cavity hoar
Alphabetical Listing
avalanche as composition
avalanche as induced cause
avalanche as motion sort
avalanche as release sort
avalanche as size
avalanche as sliding surface position
avalanche as snow humidity
avalanche as track sort
avalanche brake
avalanche breaker
avalanche bulletin (AB)
avalanche catchment area
avalanche classification
avalanche committee
avalanche cone
avalanche cord
avalanche course
avalanche data centre
avalanche defense structure
avalanche dimension
avalanche dog
avalanche dog master
avalanche dynamics
avalanche effects
avalanche exposed area
avalanche forecasting
avalanche frequency
avalanche guard
avalanche gully
avalanche hazard
avalanche hazard indicated by warning signs
avalanche interval
avalanche length
avalanche occurrence
avalanche path
avalanche pressure
avalanche probe
avalanche register
avalanche release
avalanche rescue organisation
avalanche shed
avalanche shovel
avalanche situation
avalanche slope
avalanche slope
avalanche track
avalanche victim
avalanche warning
avalanche warning service
avalanche zone plan
avalanching snow
average at 1000m and 2000m
average maximum snow depth
average velocity over cross-section
back-country skier
back-country skiing
backfilled wall
backstay
bad weather
balance velocity
balance year
ball joint
banded ogives
bang
bare ice
basal anchorage
basal ice
basal shear stress
base of the snowpack
basin
bazooka
beam
beam footing
bed roughness
bed surface
bédières
behavioural processes
bergschrund
bergy bit
bergy water
Beryllium-10 in ice
beset
big
big avalanche
big floe
biochemical processes
bio-ecological entities
biological conditions
biological parameter
biological processes
biosphere
birch
birefringence
bivouac
blaster
blasting
blasting effect
blasting licence
blizzard
blowing snow
blue ice
body components
decrease in temperature
deep basin
deep snow
defense structure
defense structure area
defenses against snow creep
deflecting barrier
deflecting force
deflecting structure
deflecting wall
deflection angle
deflection dam
deforation
deforation processes
deformed ice
degree of avalanche danger
degree of loading
density
density
density effect on deformation rate
density of constructions
density variation with depth
deposit (avalanche)
depression
depression area
depth hoar
depth hoar
depth of burial
descent
descent passage
descent route
descent track
desk roof
destabilised
destruction
detonating cord
Deuterium excess
developed area
dew
dew point
diamond dust
differential ablation
diffluent glacier
diffuse ice edge
diffusion of ice molecules
digging out
dimensions
dip
direction finding antenna
discharge above the snow surface
discharging of snow (from trees)
disciplines
displacement
distance of rope
distress signal
distribution of local risks
disturbance
diverging
double frequency rescue beacon
double T beam
down jacket
drainage glacier
draught
dried ice
drift ice
drifted snow
drifting snow
driving stress
drizzle
dropping from helicopter
drumlin
dry draught
dry snow
dry snow avalanche
dry snow line
dry stone wall
dry-snow zone
dud
dummy
dump moraine
duration of burial
dust in ice
dynamic aspects
dynamic recrystallization
dynamometer
early snow
earth fill
earth terrace for reforestation
earth terrace with toe wall
east slope
east slope
east slopes
ecological parameter
ecological processes
economic measures
ecosystems
edge effect force
effect of deformation on crystal fabrics
effective height of the defense structure
effective length of structure
effective protective measures
effective shear stress
effective stress
effective viscosity
effects and single events
elastic limit
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