SURFEX in the climate group:

Off-line global applications &
CNRM Earth System Model

Bertrand Decharme
Off-line global experiments

- **Especially relevant to evaluate:**
  - Meso-scale parameterizations from GMME
    - Hydrology
    - Snow (simple or multi-layer explicit)
    - ISBA-Ags (interactive vegetation with photosynthesis)
    - ....
  - Global parameterizations from GMGEC
    - Sub-grid hydrology
    - TRIP river routing model
    - Continental carbon cycle

- **Other applications**
  - Runoff/Discharge trends over the past and the future
  - Hydrological impacts of global warming
  - ....
Offline experiment design: Configuration – ISBA 3-L

- Plant transpiration ($E_t$)
- Surface runoff ($Q_s$)
- Rooting depth ($d_2$)
- Total soil depth ($d_3$)
- Canopy direct evaporation ($E_c$)
- Canopy dripping ($R_c$)
- Bare soil evaporation ($E_g$)
- Soil freezing sublimation ($E_{gf}$)
- Sublimation ($E_s$)
- Fonte ($S_m$)
- Diffusion
- Diffusion & drainage
- Deep drainage

References:
- Noilhan and Planton 1989
- Douville et al. 1995
- Mahfouf and Noilhan 1996
- Boone et al. 1999
- Boone et al. 2000
Spatial variability of hydrologic processes:
- Precipitation
- Topography (TOPMODEL)
- Soil properties
- Vegetation (Tiles)

Exponential profile of $k_{sat}$ with soil depth

Details will be given this afternoon during specific talk about ISBA

Decharme et al. 2006; Decharme et Douville 2006
**Offline experiment design**

**USER**
Atmospheric forcing:
Princeton Univ. + GPCC
3-hr, 1°

SURFEX
Offline experiment: Atmospheric forcing

1986-2006 Average (Princeton University)
Offline experiment design

**USER**
Atmospheric forcing:
Princeton Univ. + GPCC
3-hr, 1°

**SURFEX**

**PGD.exe**
Sol and vegetation parameters
1°
ECOCLIMAP 1km
Offline experiment design: **PGD.exe**

- **.TRUE.** = Use of ECOCLIMAP
- **Grid configuration**
  - Model used (here only ISBA)
  - Arrange the covers:
    - Marshes in vegetation type
    - Town cover in Rock
  - 1km ECOCLIMAP file to be read
    - Remove covers < grid cell fraction XRM_COVER
    - Remove inland coast < grid cell fraction XRM_COAST
Offline experiment design: **PGD.exe**

- **.TRUE.** = Use of ECOCLIMAP
- **Grid configuration**
- **Model used (here only ISBA)**
- **Arrange the covers:**
  - Marshes in vegetation type
  - Town cover in Rock
  - 1km ECOCLIMAP file to be read
  - Remove covers < grid cell fraction XRM_COVER
  - Remove inland coast < grid cell fraction XRM_COAST
  - 1km GTOPO file to be read
Offline experiment design: PGD.exe

1° continental topography from GTOPO30
Offline experiment design: **PGD.exe**

- **.&amp;AM_FRAIC**
  - **LECOCLIMAP = T**
  - **.TRUE.=Use of ECOCLIMAP**

- **&amp;AM_PGD_Grid**
  - **CGRID = 'LONLAT REG'**

- **&amp;AM_LONLAT_REG**
  - **XLONG = -180.**
  - **XLONG = 180.**
  - **XLATMIN = -60.**
  - **XLATMAX = 90.**
  - **NLONG = 360.**
  - **NLAT = 150.**

- **&amp;AM_PGD_SCHEMES**
  - **CNATURE = 'ISBA'**
  - **CSEA = 'NONE'**
  - **CTOWN = 'NONE'**
  - **CWater = 'NONE'.**

- **&amp;AM_PGD_ARRANGE_COVER**
  - **LWATER_TO_NATURE = T**
  - **LTOWN_TO_ROCK = T**

- **&amp;AM_COVER**
  - **YCOVER = 'ecoclimate_v2'**
  - **YFILETYPE = 'DIRECT'**
  - **XRM_COVER = 0.01**
  - **XRM_COAST = 0.6**

- **&amp;AM_ZS**
  - **YZS = 'gtopo30'**
  - **YFILETYPE = 'DIRECT'.**

- **&amp;AM_ISBA**
  - **YCLAY = 'clay_fao'**
  - **YCLAYFILETYPE = 'DIRECT'**
  - **YSAND = 'sand_fao'**
  - **YSANDFILETYPE = 'DIRECT'**
  - **YCTI = 'topo_index'**
  - **YCTIFILETYPE = 'DIRECT'**
  - **XUNIF_WDRAIN = 0.0005**
  - **CISBA = '3-L'**
  - **NGROUND_LAYER = 3**
  - **NPATCH = 12**

- **&amp;AM_IO_OFFLINE**
  - **CSURF_FILETYPE = 'FA'**
  - **CTIMESERIES_FILETYPE = 'FA'.**

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Grid configuration

Model used (here only ISBA)

Arrange the covers:
- Marshes in vegetation type
- Town cover in Rock

1km ECOCLIMAP file to be read
- Remove covers < grid cell fraction XRM_COVER
- Remove inland coast < grid cell fraction XRM_COAST

1km GTOPO file to be read

10km FAO (soil texture) file to be read
Offline experiment design: **PGD.exe**

\[ \text{sand} \]

\[ \text{Clay} \]

Not know so SURFEX performs an interpolation (Nearest grid points)

1° sand and clay fractions from **FAO**
Offline experiment design: **PGD.exe**

- **.TRUE.** = Use of ECOCLIMAP

  - **Grid configuration**

- Model used (here only ISBA)

  - **Arrange the covers:**
    - Marshes in vegetation type
    - Town cover in Rock

  - **1 km ECOCLIMAP file to be read**
    - Remove covers < grid cell fraction XRM_COVER
    - Remove inland coast < grid cell fraction XRM_COAST

  - **1 km GTOPO file to be read**

  - **10 km FAO (soil texture) file to be read**

  - **1 km Topo indexes (TOPMODEL)**
In ISBA, the TOPMODEL based approach used Topo index statistics ($\text{min, max, mean, std and skewness}$) to simulate surface runoff in each 1° grid-cells.

1° Topo index (max) used by TOPMODEL
Offline experiment design: **PGD.exe**

### Grid Configuration
- **Grid configuration :**
  - Use of ECOCLIMAP
  - Model used (here only ISBA)
  - Arrange the covers:
    - Marshes in vegetation type
    - Town cover in Rock

### Model Used
- **Model used (here only ISBA):**
  - 1km ECOCLIMAP file to be read
  - Remove covers < grid cell fraction XRM_COVER
  - Remove inland coast < grid cell fraction XRM_COAST

### ISBA Configuration
- **ISBA configuration:**
  - 10km FAO (soil texture) file to be read
  - 1km Topo indexes (TOPMODEL)
  - ISBA configuration

### I/O Format
- **I/O Format:**
Offline experiment design

**USER**
Atmospheric forcing:
Princeton Univ. + GPCC
3-hr, 1°

**SURFEX**

**PGD.exe**
Sol and vegetation parameters
ECOCLIMAP 1km

**PREP.exe**
Initialization of prognostic variables
ARPEGE GRIB file 1°
Offline experiment design: PREP.exe

1° prognostic variable: Glaciers
Offline experiment design

**USER**
Atmospheric forcing:
Princeton Univ. + GPCC
3-hr, 1°

**SURFEX**
Initialization of prognostic variables
GRIB file

**PREP.exe**
GRACE observations
PGD.exe
Sol and vegetation parameters
ECOCLIMAP 1km

**OFFLIN.exe**
Evaporation
Runoff

**TRIP**
1° or 0.5°
Discharge

GRACE observations
in situ observations

Soil moisture, snow, free water climatology
Terrestrial Water Storage = soil moisture + snow + river + plant interception
SURFEX-TRIP vs. GRACE and Discharges

**Interannual variability**

![Graphs showing interannual variability of GRACE and Discharges](image)

**Annual Cycle**

![Graphs showing annual cycle of ISBA components](image)

ISBA = Soil moisture + Rivers water content + Snow

r=0.96  RMSE=0.52  Ratio=1.09  Eff=0.69

(Alkama et al. 2009, J. Hydromet, submitted)
SURFEX-TRIP vs. GRACE and Discharges

Interannual variability

Annual Cycle

Variable flow velocity in TRIP (Manning formula)

(Decharme et al. 2009, J. Hydromet, submitted)
Annual cycle of snow fractions

(Alkama et al. 2009, J. Hydromet, submitted)
Prospect

Atmosphere

Land surface

Vertical

Horizontal

Vegetation

Snow

Permafrost

Groundwater

Floodplains

TRIP

Deep soil

Ocean

CO₂, CH₄

CO₂, CH₄
Prospect: Floodplains

Satellite-derived wetland estimates from Prigent et al. (2007, JGR).

ISBA-TRIP floodplains simulation

Difference

(Decharme et al. 2008, JGR, 113)
SURFEX in Earth System Model

- **ARPEGE V5 (T127 ~1.4°)**
  - To SURFEX:
    - Sea/ice fraction
    - SST (sea/ice)
    - Albedo ice
  - From SURFEX
    - Runoff
    - Drainage

- **SURFEX V5 (T127 ~1.4°)**
  - Coupling
  - OASIS

- **GELATO (1°)**
  - From SURFEX
    - Runoff
    - Drainage

- **NEMO (1°)**
  - From SURFEX
    - Runoff
    - Drainage
Test in SST (ERA-40) forced mode (1990-1999): 2m Air Temperature bias to CRU2

Without SURFEX (Very simple ISBA)

SURFEX but same previous hydrology

SURFEX with same “off-line” hydrology
SURFEX in Earth System Model

- **Especially relevant to study climate sensibility to:**
  - Continental processes:
    - Hydrology
    - Snow
    - Carbon cycle
    - Land use
  - Ocean fluxes parameterizations:
    - Simple (Louis)
    - ECUME
    - ...

- **Important applications (CNRM/CERFACS)**
  - IPCC (Starting debut 2010)
  - Seasonal and ten-years forecast
  - ....
Test in SST (ERA-40) forced mode (1990-1999): Precipitation bias to GPCC

Without SURFEX

SURFEX but same previous hydrology

SURFEX with same “off-line” hydrology