The Canadian RCM : general overview of the model and specific features of the Narccap simulations

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with contribution from the
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CRCM v4.2.0 (version used for the Narccap simulations)

Dynamics
semi-implicit semi-Lagrangian algorithm
Arakawa-C grid on polar stereographic projection
Gal-Chen scaled-height vertical coordinates
Davies nesting
large-scale nudging (aka spectral nudging)

Physics	
Surface scheme	CLASS 2.7 (3 layers + Snow) soil: Wilson & Henderson-Sellers 1° veg: GLC2000 1km > 1°
Convection and large scale condensation	Bechtold-Kain-Fritsch Super saturation removal
Radiation	SW Fouquart & Bonnel LW Morcrette
Clouds	diagnostically based on relative humidity & conditional stability

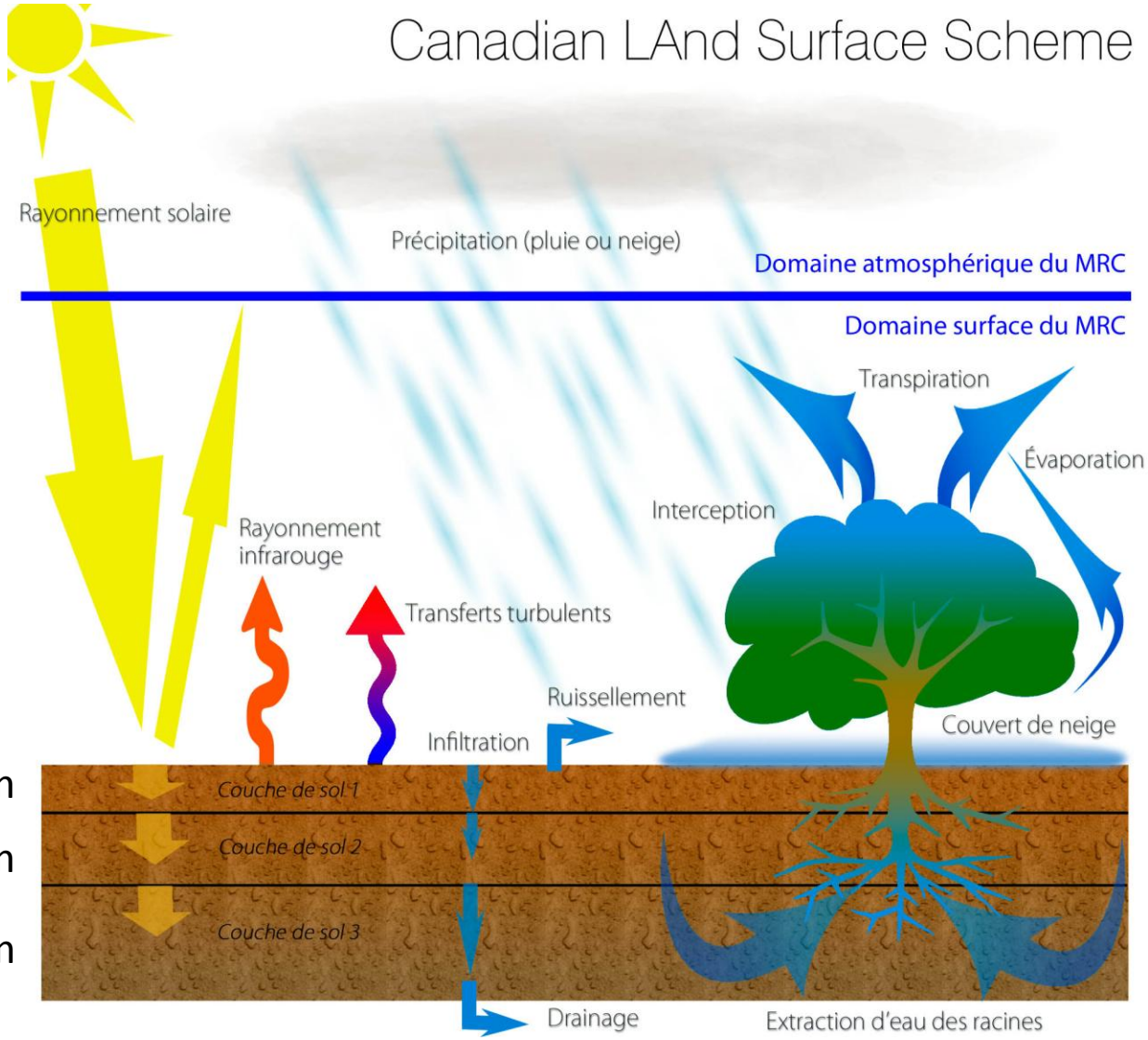
CLASS (MRCC4.x)

VÉGÉTATION
Conifères
Feuillus
Cultures
Herbes

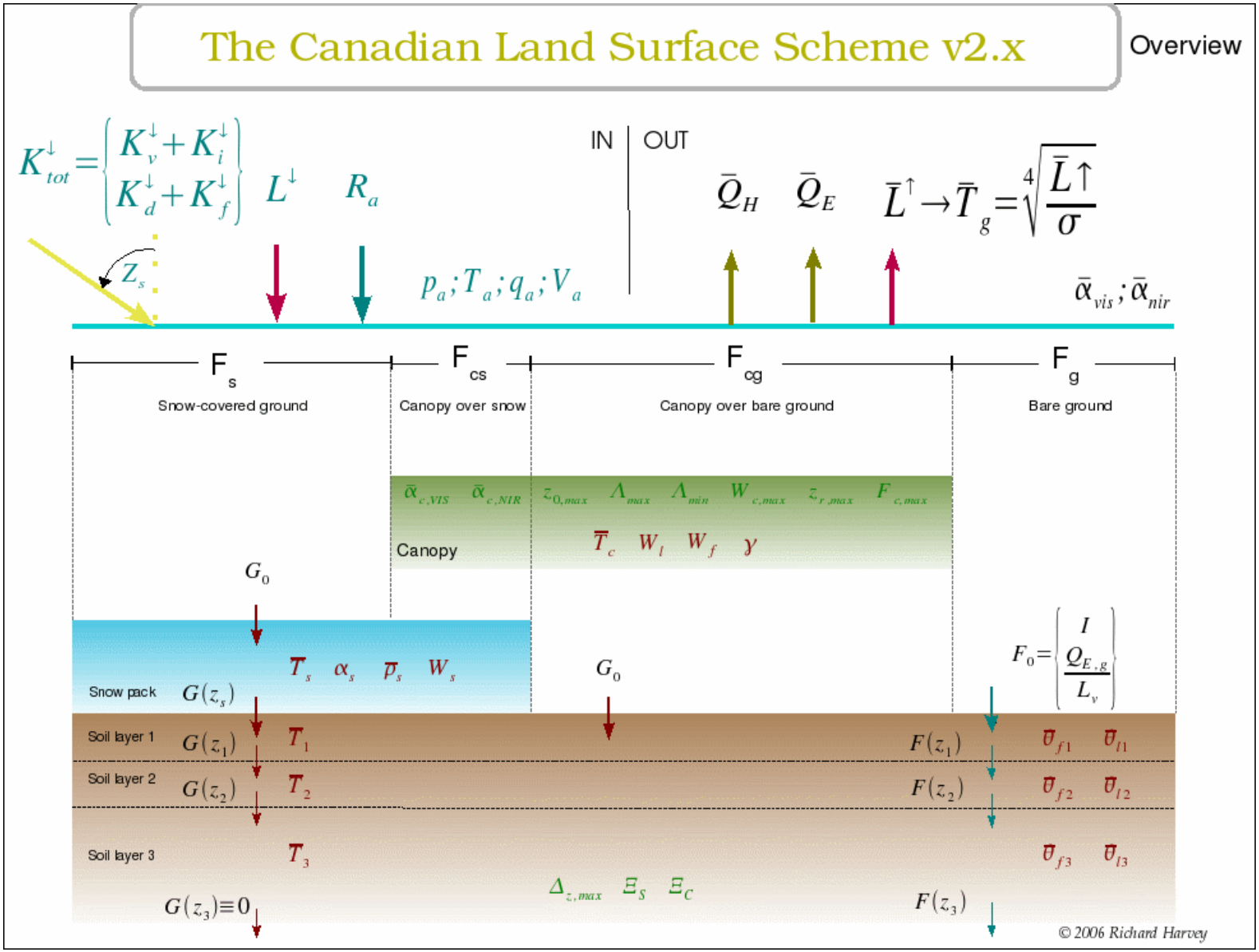
NEIGE
comme une couche de « sol » supplémentaire

SOL
Trois textures pour chaque couche
- Sable
- Argile
- Matière organique

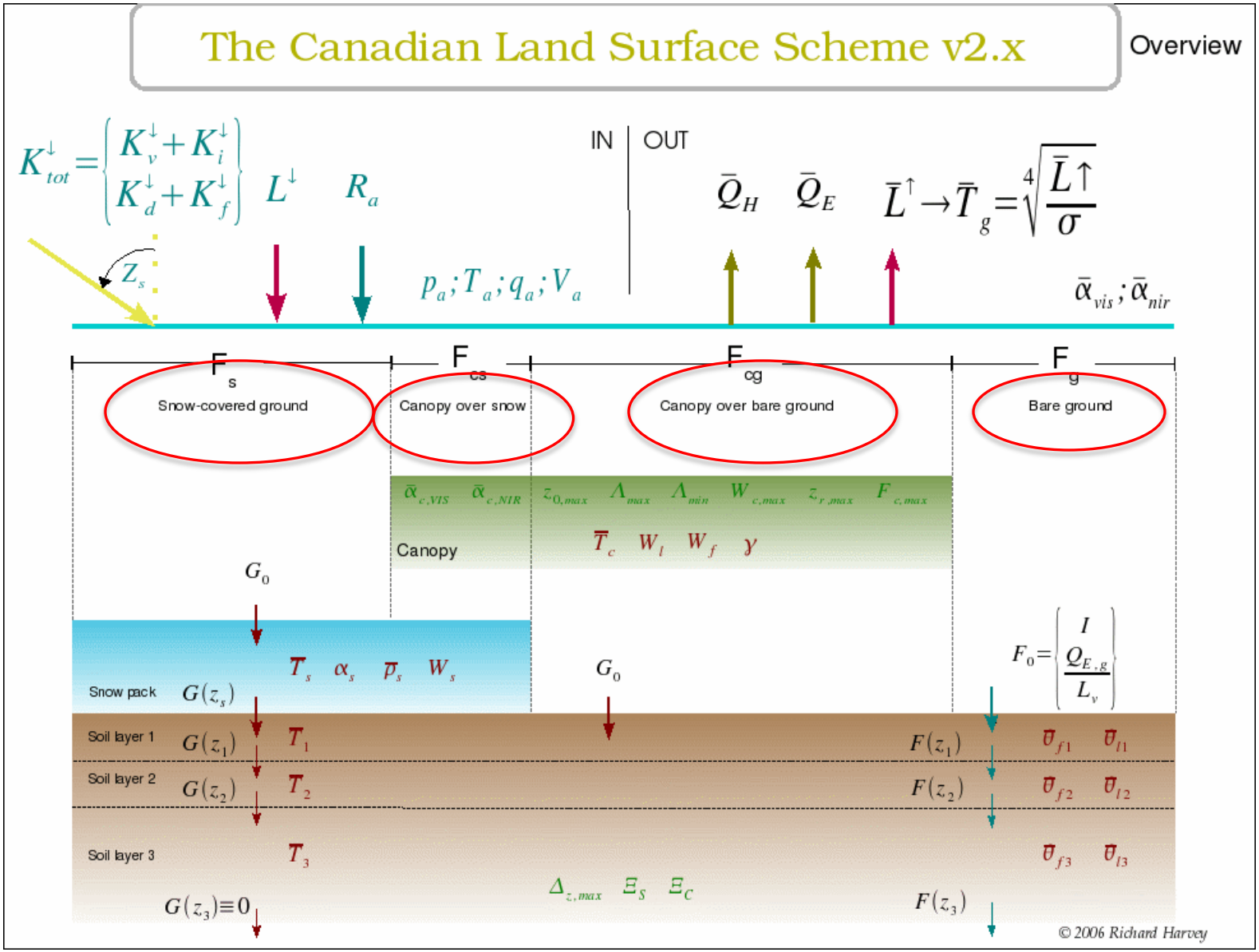
CLASS 3.5
n couches et profondeur arbitraires



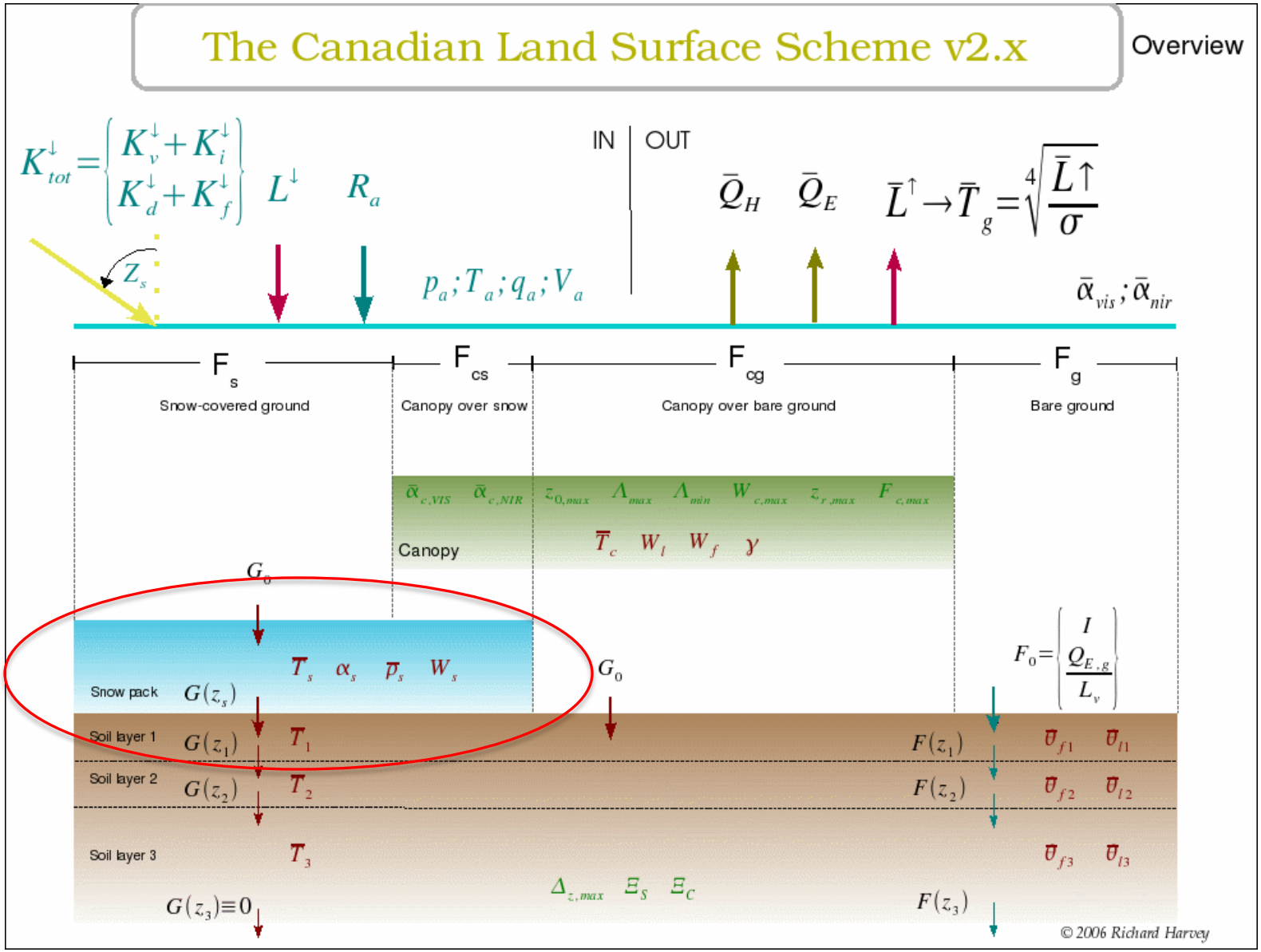
2nd generation surface scheme with 3 soil layers



Each cell is divided in 4 sub-regions



Sowpack treated as explicit 4th layer

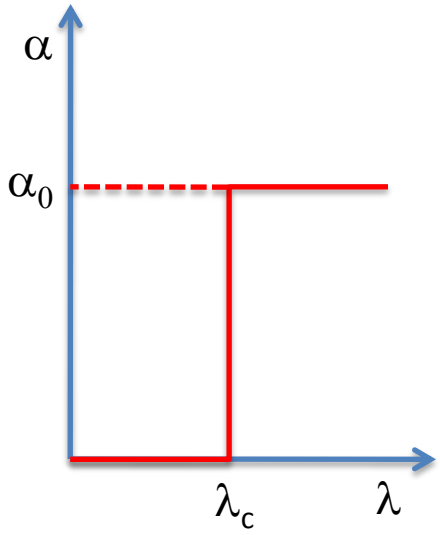


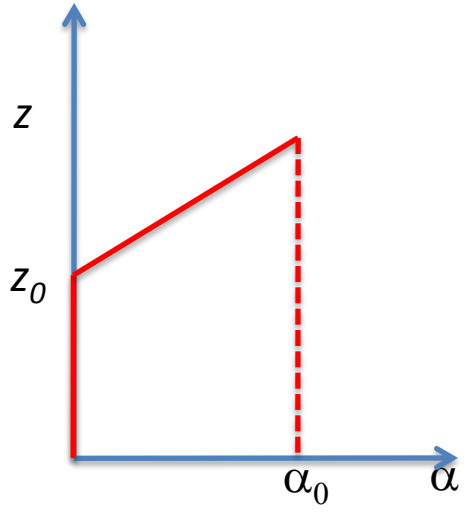
Large-scale Nudging.

Modification of a prognostic variables *X* with the following equation :

$$X^{+}_{RCM} = (1-\alpha)X_{RCM} + \alpha X_{LBC}$$

Where X_{RCM} is the value of *X* from the RCM, X_{LBC} is the value of *X* from the LBC and α is a function of the length scale λ and the altitude *z*.





Only the fields higher than altitude z_0 and with scale larger than λ_c are affected by the large-scale nudging.

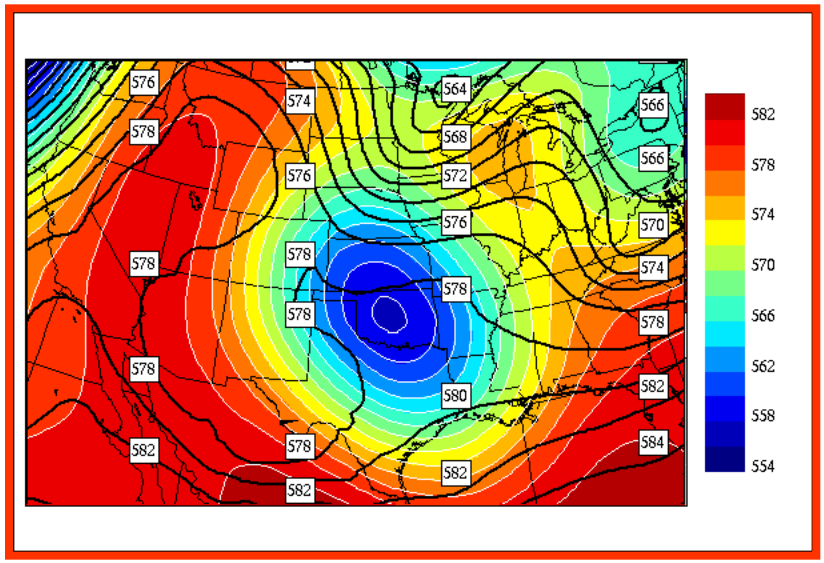
Tyically, λ_c = 1400km, z_0 = 500 hPa and *X* = horizontal wind

Large-scale Nudging.

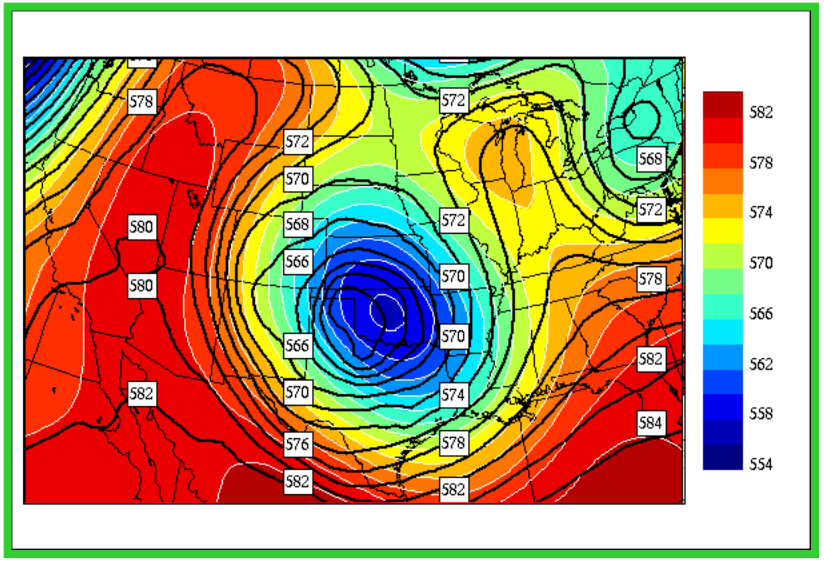
Motivations to use LSN

•Reduction of the mismatch between the RCM and the LBC at the outflow boundary and prevents the development of large discrepencies between the LBC and the RCM

Without LSN



With LSN



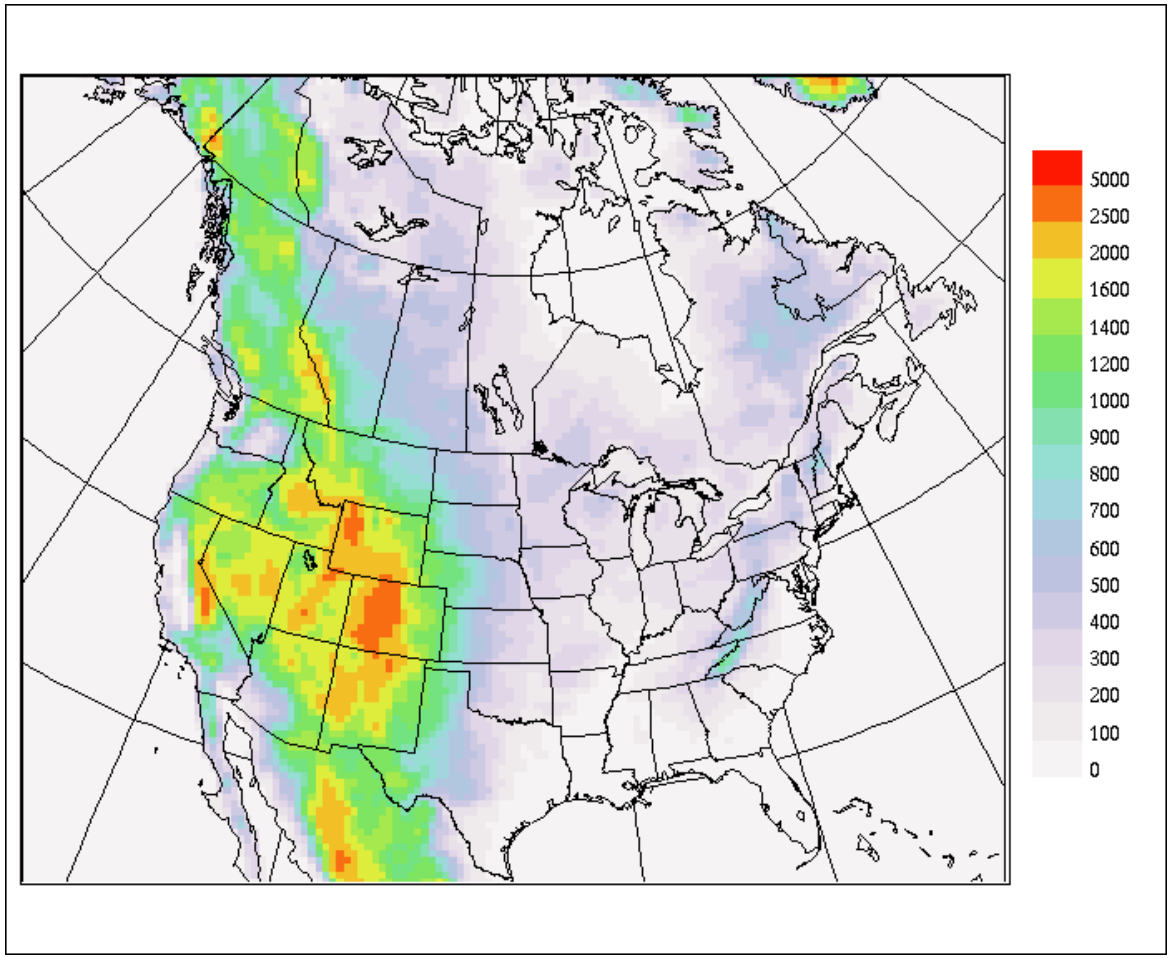
CRCM(blacklines) and NCEP(color) analysis GZ 500 hPa [dam] on 22 May 1988 at 12Z (i.e. 180 h of simulation)

Large-scale Nudging.

Motivations to use LSN

- Reduces the mismatch between the RCM and the LBC at the outflow boundary and prevents the development of large-scale differences between the driving model and the RCM
- Reduces the sensitivity of a simulation to the size of the domain
- Side effects seem minimal (*c.f.* Alexandru *et al 2009,* MWR)

Set-up for the Narccap simulations



- CRCM version 4.2.0
- 160x135 computation grid
- 10 points Davies nudging on the perimeter
- 29 vertical levels to 10 hPa
- 140x115 diagnostic grid (grid of the NetCDF files)
- Polar stereographic grid with 50 km resolution @ 60deg. N
- 900s time-step

Other specific questions

- Soil initialisation?
- Spin-up length?

Soil initialization

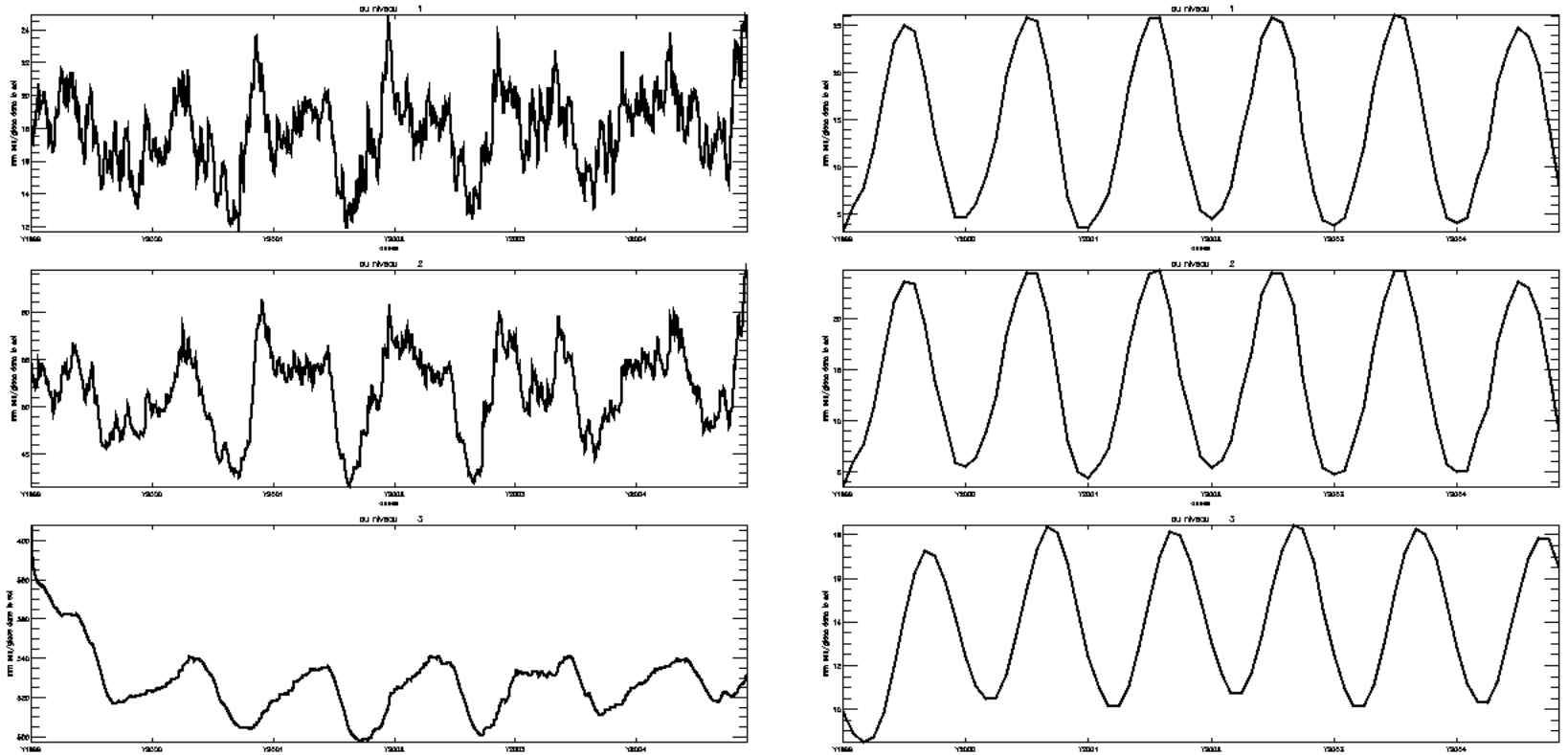
- Some surface variables are prognostic and only need to be initialized (*e.g.* soil moisture, temperature, snow cover, …)
- Some surface variables are prescribed with different update frequencies (*e.g.* SST, Sea ice, Root depth, ozone, …)

Details :

- Deep soil initial values are taken from a 3-year CGCM3 simulation
- Topography and Ground Cover are taken from 1/6x1/6 deg US Navy datset
- Vegetation fields : GLC2000 dataset interpolated on 1x1 deg grid
- SST and Sea ice :
    - Using reanalysis LBC : lake and ocean use the AMIP2 values
    - Using a given GCM for LBC : ocean uses the CGCM3 SSTs and Lake uses a lake model with flux correction.
- Other variables : initialized by a climatology of the CGCM3

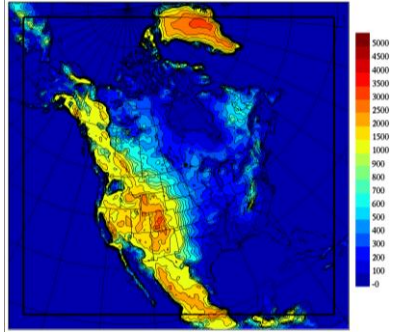
Spin-up period

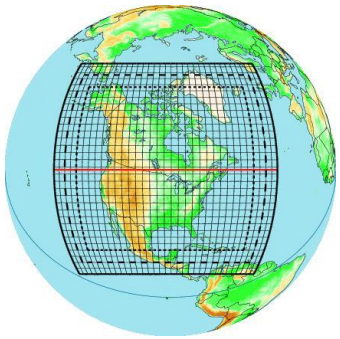
- We use 3 years of spin-up
- Order of time taken for the deepest soil layer to reach steady state.



Time evolution of soil moisture (left) and temperature (right) for the three soil layer over a region covering approximatively the contiguous USA (courtesy of Dominique Paquin)

Thank you





	CRCM4 (v4.2.3) 201x193, 29L, @45km	CRCM5 (v3.3.0) 178x158, 53L, @0.5°	CRCM5C (v3.3.0) 178x158, 53L, @0.5°	CRCM5V (v3.3.0) 180x158, 35L, @0.5°
Surface scheme	CLASS 2.7 (3 lyrs) soil: Wilson & Henderson-Sellers 1° veg: GLC2000 1km > 1°	ISBA (2lyrs) soil: USDA 1km AGRC 10km FAO 1° veg: USGS 1km	CLASS 3.4 (3 lyrs, no mosaïc) organic soil snow (Brown) soil: Wilson & Henderson-Sellers 1° veg: USGS 1km	CLASS 2.7 (3 lyrs) soil: Webb (1993) Veg : Wilson & Henderson-Sellers
Convection and large scale condensation	Bechtold-Kain-Fritsch sursaturation removal	Kain-Fritsch Sundqvist	Kain-Fritsch Sundqvist	Zhang-McFarlane sursaturation removal
Radiation	SW Fouquart & Bonnel LW Morcrette	RRTM correlated-K	RRTM correlated-K	RRTM correlated-K
Clouds	diagnostically based on relative humidity excess & conditional stability	based on relative humidity with vertically varying threshold	based on relative humidity with vertically varying threshold	statistical cloud scheme
Spectral nudging	yes	no	no	no

CRCM_4.2.3

•semi-implicit semi-Lagrangian algorithm

•Arakawa-C grid on polar stereographic projection

•Gal-Chen scaled-height vertical coordinates.

•nesting follows Davies over the sponge zone (9-grid points)

•large-scale nudging (*Biner et al*. 2000) is applied over the entire domain for horizontal wind over 500 hPa

•physical parameterization follows AGCM3, including CLASS_V2.7 surface scheme (3 layers), but moist convection follows Bechtold-Kain-Fritsch

•201x193 grid points (182 x 174)

•45 km true at 60 N.

•29 vertical levels

•Dt 900 sec.

•Pilot ERA40 at 2.5 deg and AMIPII 1 deg