# An overview of the surface in ERA-40

Pedro Viterbo

*ECMWF, Reading, U.K*

## Layout

- **Scope of this presentation**
- **The laundry list of modifications**
- **Winter water and energy budgets**
- **Summer water and energy budgets**
- **Spring water and energy budgets**
- **Some results for sea ice**
- **Conclusions and outlook**

## Scope of presentation

- **A road map to the use of ERA40 over land and sea ice**

  **OR**
- **The Lonely Planet guide to the surface at ERA40**
  - **Tourists want the thrill of going to exotic locations**
  - **Researchers want the thrill of looking at "exotic" variables (soil wetness, surface fluxes …)**

  **But they also want to know of "safe havens", ie**
  - **Where to find food, a beer and accommodation (tourists)**
  - **Known properties of model and assimilation systems (researchers)**

- **1992 is taken as a representative year**
- **Monthly mean results**
  - **Fluxes from 12-24 forecasts starting at 00/12 UTC**
  - **Variables from 18/24 forecasts starting at 00/12 UTC**
  - **But two-metre daily maxima/minima from 6/12/18/24 forecasts starting at 12 UTC**
- **ERA40 vs ERA15**
- **Tropics will be largely ignored**
- **All fluxes are positive downward**
- **NB: Sea is blanked out from all plots (except for sea ice plots, where land is blanked out)**

**Scope 2**

## Model changes ERA40 – ERA15 (1)

- **Radiation**
  - Longwave radiation (RRTM)
  - Shortwave radiation (4 spectral intervals)
- **Convection and clouds**
  - CAPE closure
  - Evaporation of rain
  - Several modifications to the cloud scheme
- **Vertical diffusion**
  - Doubling of the resolution in the boundary layer (13 levels below 1500 m; 15 levels below 2000 m; lowest model level at 10 m)
  - More efficient downward sensible heat transfer in stable situations at the surface

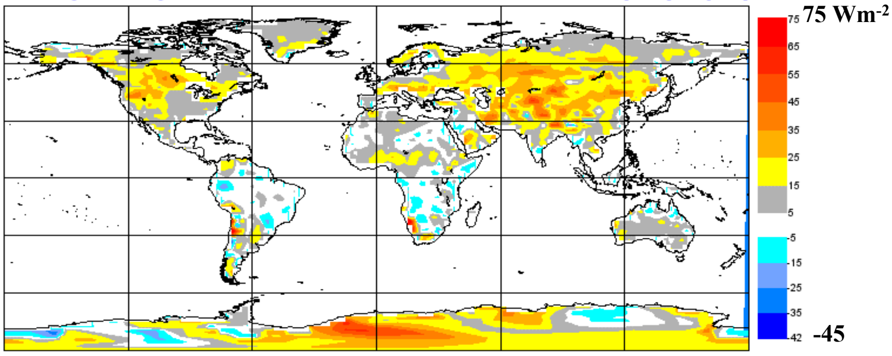
**Modifications list 1**

- **Land surface**
  - Thermal effects of soil freezing
  - Albedo of forested areas in the presence of snow
  - TESSEL: Frozen soil hydrology
  - TESSEL: Tiling of the land surface, including
    - Low/High vegetation
    - Exposed snow (bare ground and shrubs/grass) / Shaded snow (forests)
  - TESSEL: Biome differentiation (root profiles, canopy resistance, LAI)
  - New (and seasonal) background albedo
  - TESSEL: New snow scheme
    - Independent energy content
    - Prognostic snow albedo and density
- **Revised snow analysis**
  - Use of model density
  - New climate (to default to in sparse observation areas)
  - More data: Canada, FSU

**Modifications list 2**

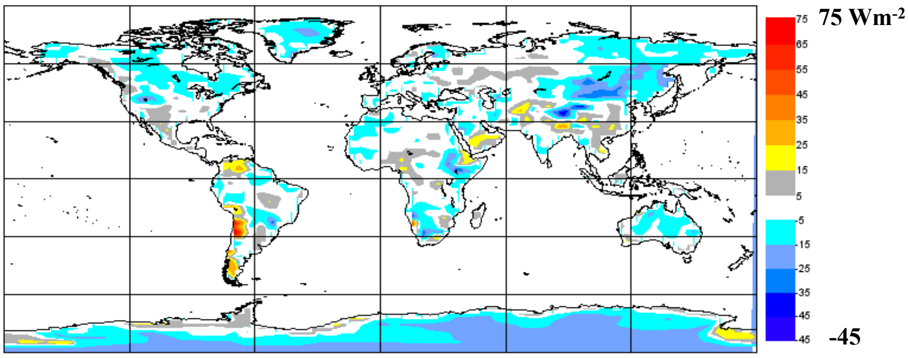
## Downward LW radiation January

**E40 – E15**




**•Increased downward LW in winter hemisphere (RRTM ?)**

Winter budgets 1

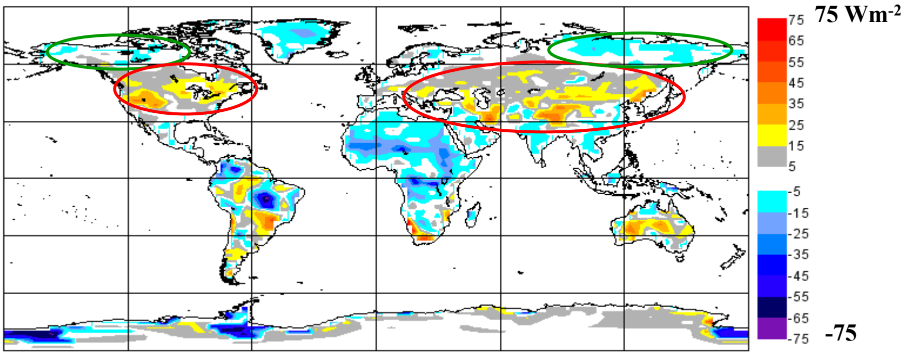



**•Increased net upward LW, due to warmer surface temperatures**

Winter budgets 2

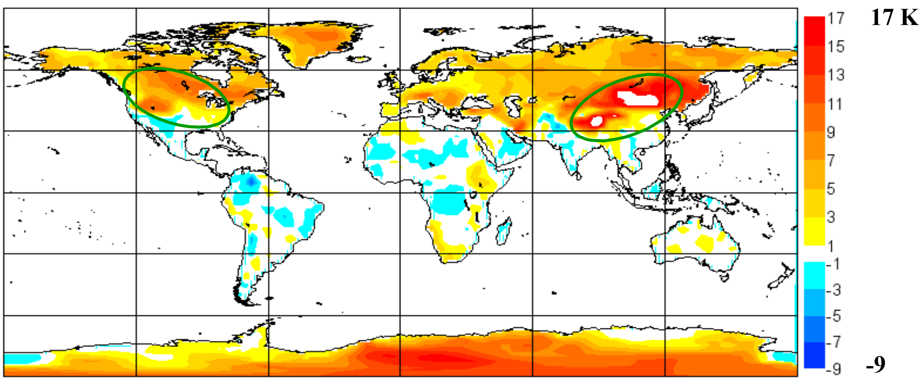
## Net radiation January

**E40 – E15**




- **Reduced net radiation in polar latitudes (north of 60 N), associated with warmer surface temperatures**
- **Increased net radiation in mid-latitudes (south of 60 N), due to decreased albedo of snow covered areas**

**Winter budgets 3**

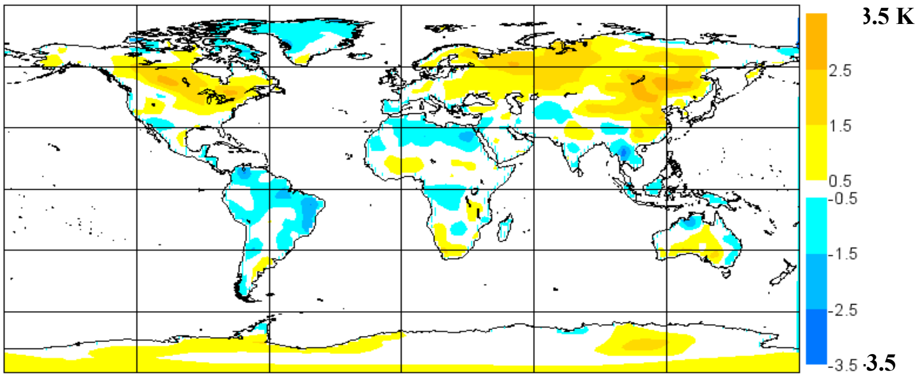



- **E40 much warmer than E15**
- **At polar latitudes the thermal effects of soil freezing dominate the pattern**
- **This is compounded with the effects of lower albedo in snow covered areas**

**Winter budgets 4**

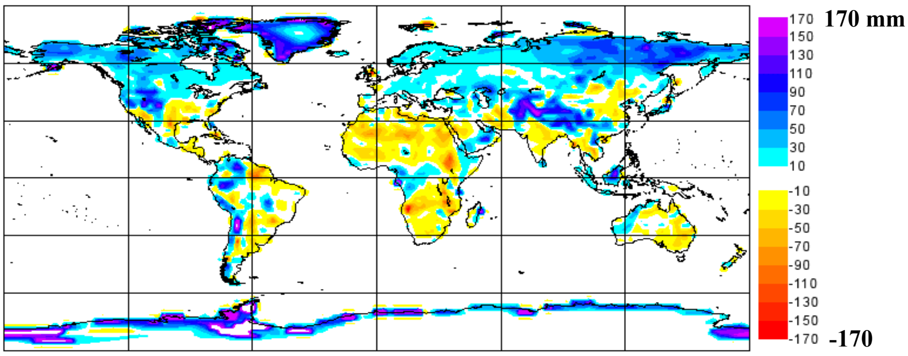
## Daily max two-metre temperature January

**E40 – Analysis**




- **Although E40 is too warm, it is still closer to the observations than E15, which had an extremely cold bias**
- **The residual warm bias is not well understood: Increased skin-soil thermal coupling is one factor**

**Winter budgets 5**

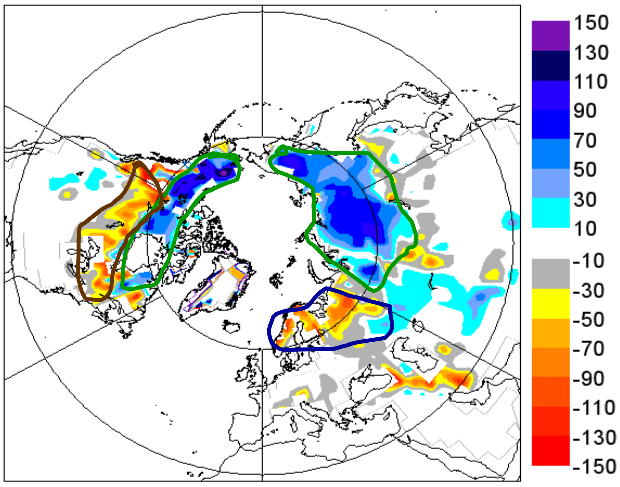



- **Increased soil water in high latitudes, due to reduced drainage in partially frozen soils**

**Winter budgets 6**

## Snow mass January

E40 – E15



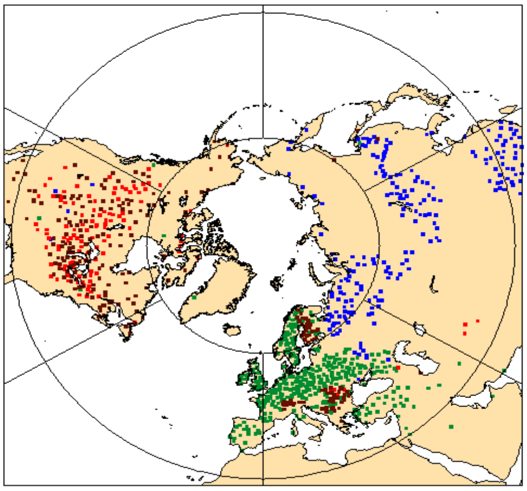

150 $kgm^{-2}$

-150

- Different climate, with more snow depth in high latitudes
- Different usage of observations
- More observations

Winter budgets 7

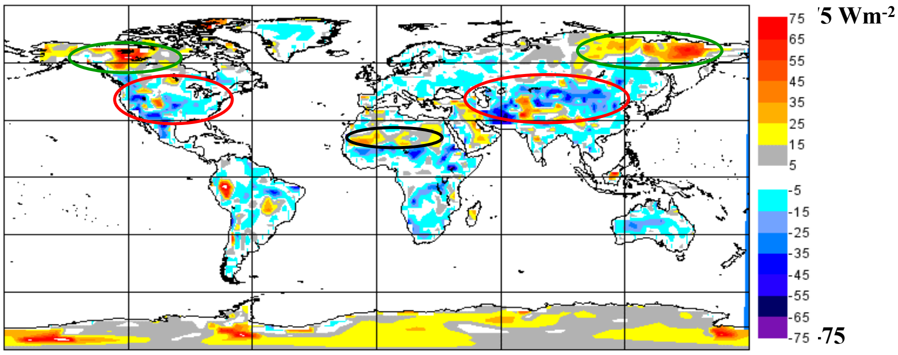
19920115 snow observations 00 blue 06 green 12 red 18 brown



Winter budgets 8

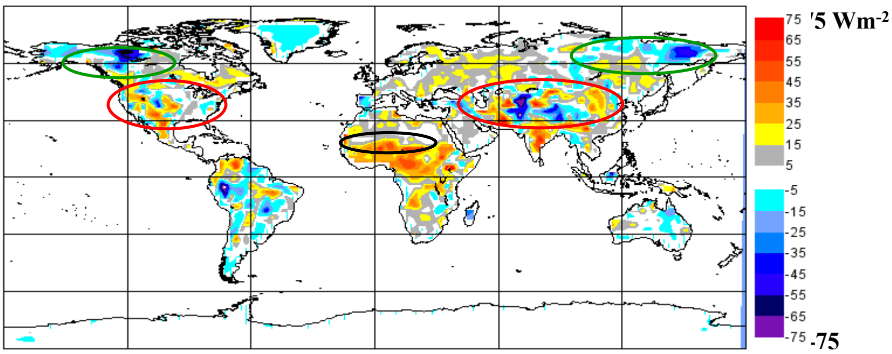
## Sensible heat flux July

**E40 – E15**




- **Increased (upward) sensible heat flux in mid-latitudes**
- **Reduced sensible heat flux in polar latitudes**

**Summer budgets 1**

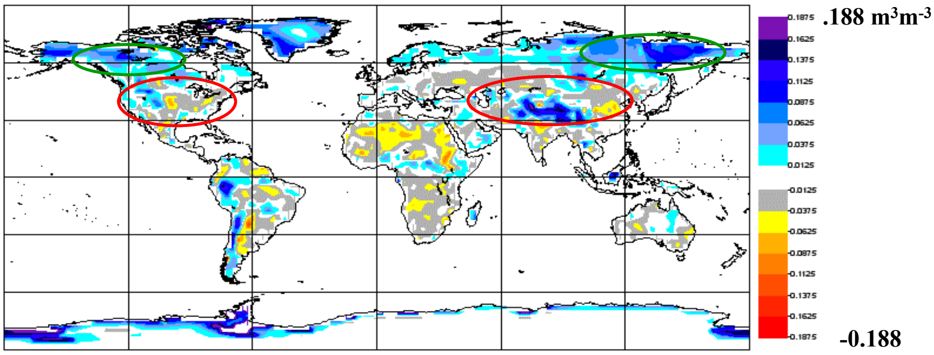



- **Reduced latent heat flux in mid-latitudes**
- **Increased latent heat flux in polar latitudes**
- **Sub-Sahelian Africa has reduced sensible and latent heat flux: increased albedo**

**Summer budgets 2**

## Soil water layer 3 (28-100 cm) July

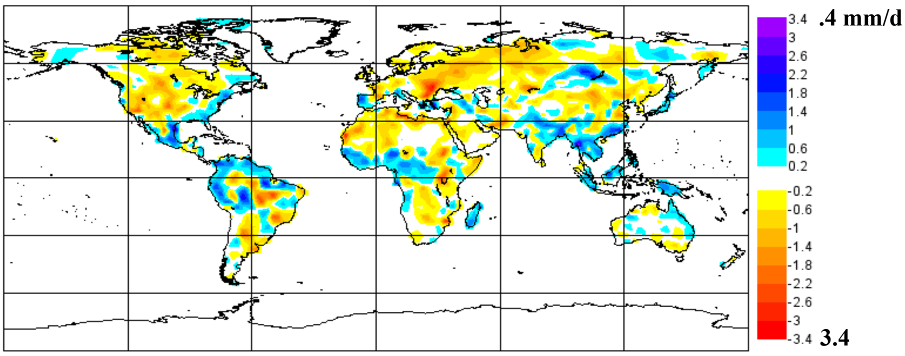
**E40 – E15**




**•Drier soil in mid-latitudes, associated to reduced soil water increments**

**•Moister soil in polar latitudes, due to reduced loss of water in spring due to limited drainage**

**Summer budgets 3**

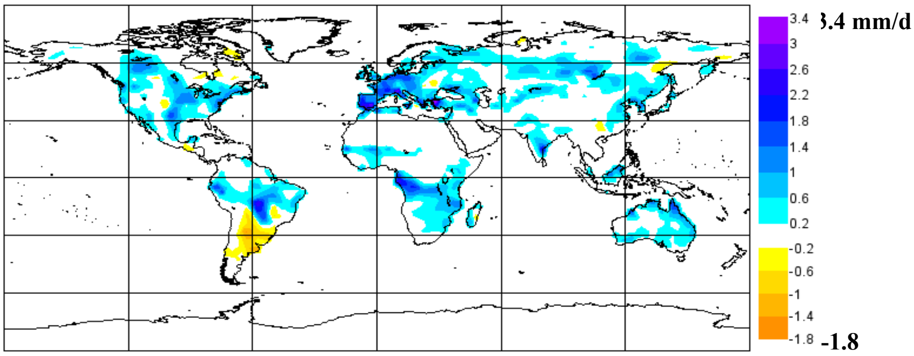



**•Reduced soil water increments in mid-latitudes, due to a better analysis and a better model**

**Summer budgets 4**

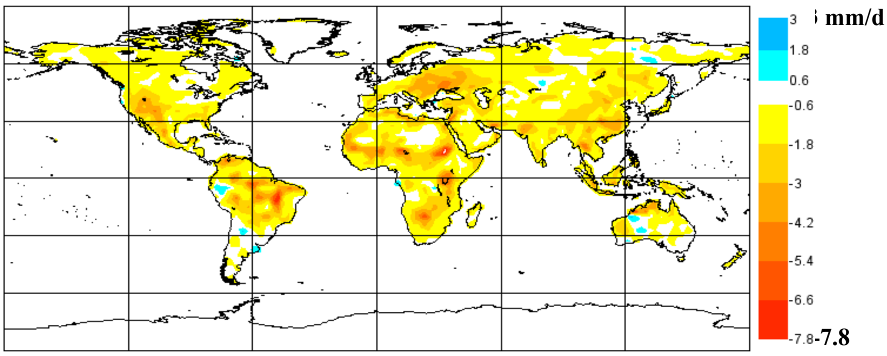
## Mean soil water analysis increments August

E40




•Reduced role of soil water increments in the seasonal evolution of soil water: Increments are below 1 mm/day, except in SW Europe, where they reach 2 mm/day.

Summer budgets 5

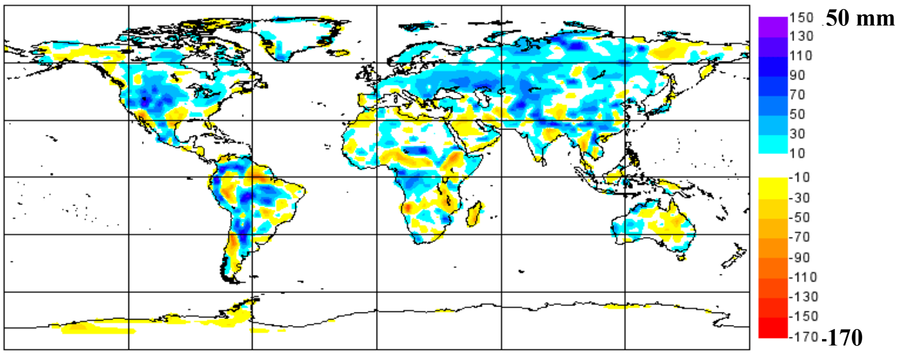



•Much reduced standard deviation of increments (E15 increments have a diurnal cycle …)

Summer budgets 6

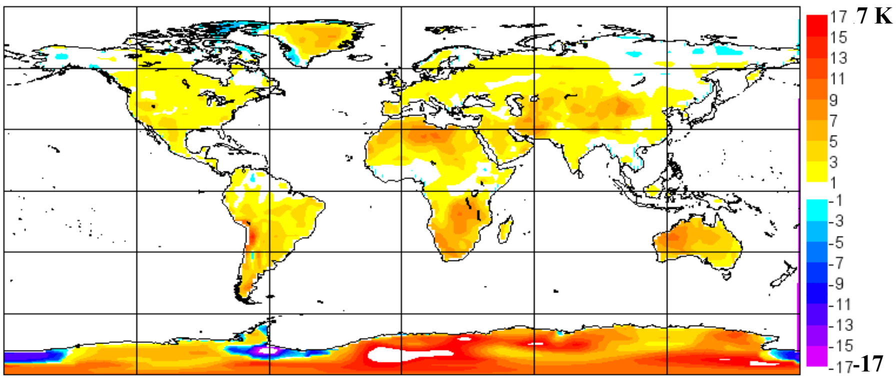
## Soil water seasonal amplitude (February – August)

**E40 – E15**




**•Increased seasonal amplitude of soil water: Wetter soil in winter (reduced drainage), drier soil in summer (reduced increments).**

**Summer budgets 7**

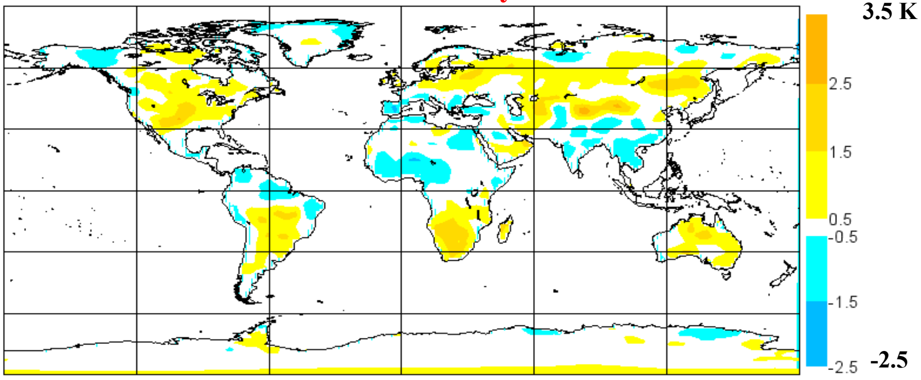



**•Increased minimum temperature due to: (a) Increased night time downward sensible heat flux; (b) Stronger skin-soil thermal coupling**

**Summer budgets 8**

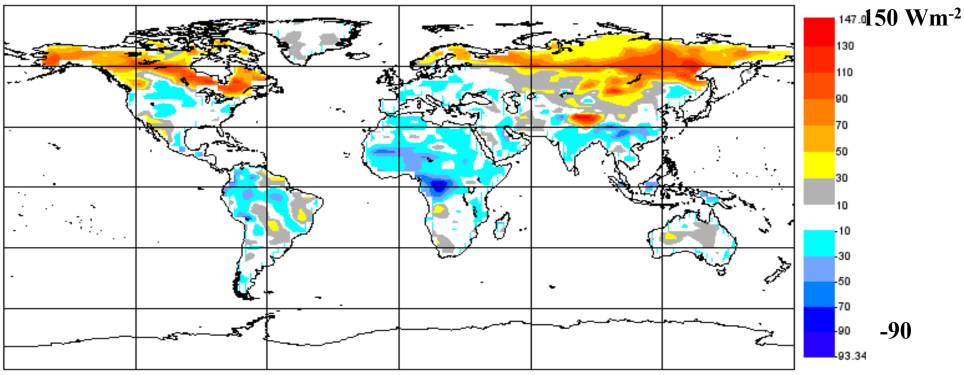
## Daily minimum two-metre temperature July

### E40 – analysis




**•In most areas in mid-latitudes, E40 has a warm bias in night-time temperatures**

**Summer budgets 9**

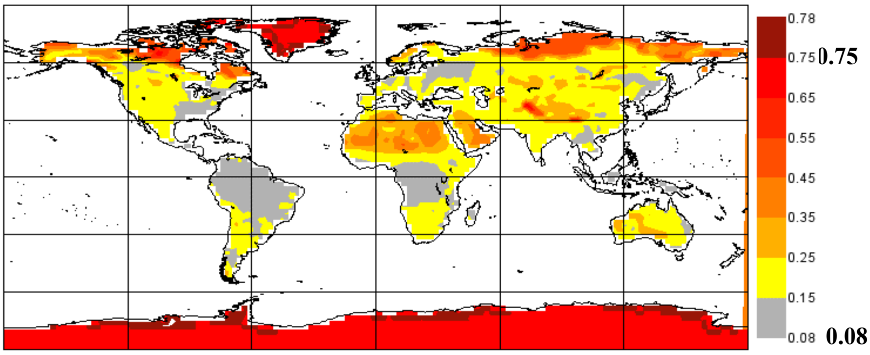



**•Increased SW radiation in snow-covered areas**

**Spring budgets 1**

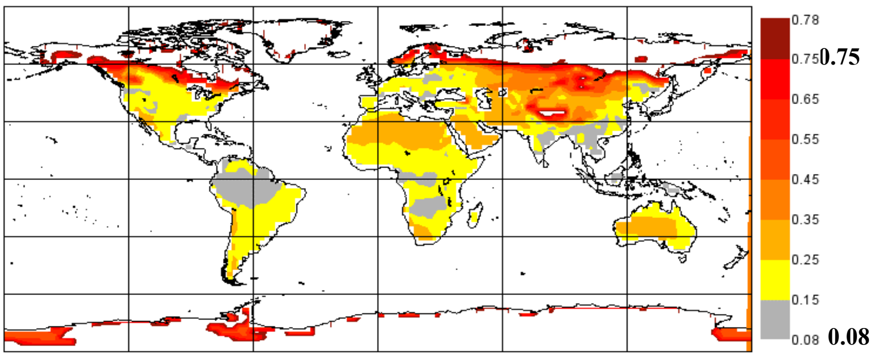
## "Forecast" albedo April

### E40




**•In E40, the albedo of snow covered areas is of the order of 0.2-0.3 in forests, and 0.5-0.6 in tundra/barren surfaces**

Spring budgets 2

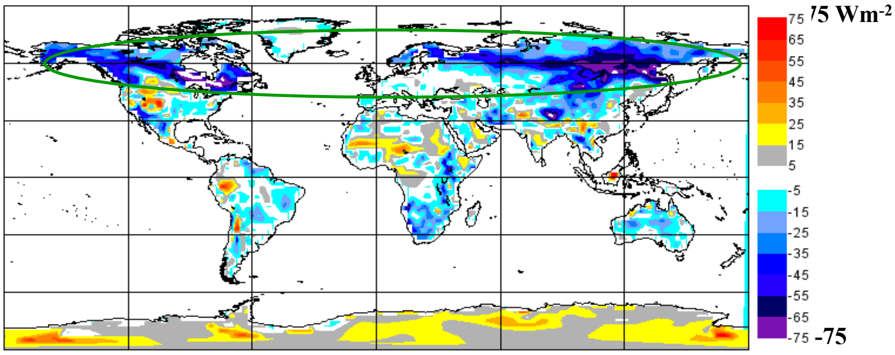



**•In E15, the albedo of snow covered areas exceeds 0.5 everywhere, and reaches 0.8 in high latitudes**

Spring budgets 3

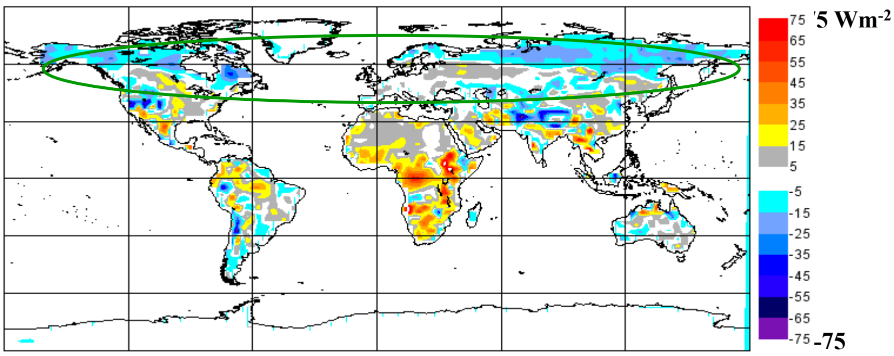
## Sensible heat flux April

**E40 – E15**




**•Increased sensible heat flux, due to higher available energy at the surface**

Spring budgets 4

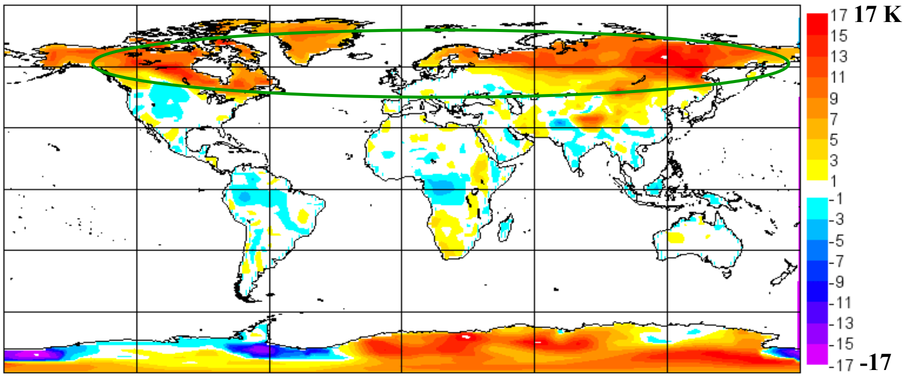



**•Increased latent heat flux, but not as much as the sensible heat flux; frozen soils limit transpiration in E40**

Spring budgets 5

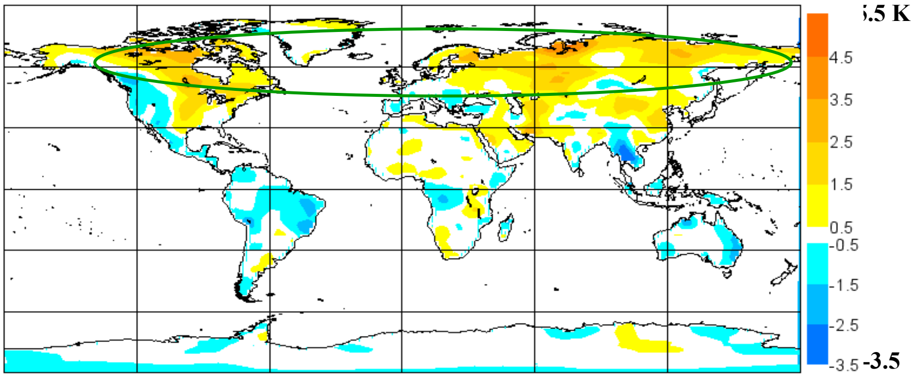
## Daily maximum two-metre temperature April

### E40 – E15




•E40 much warmer than E15 during day time

Spring budgets 6

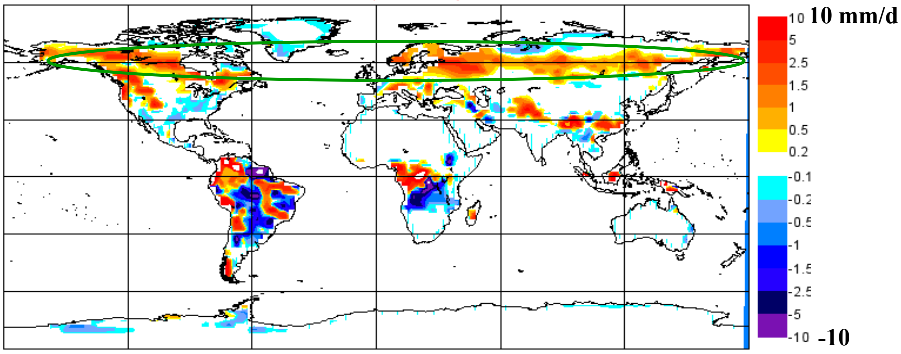



•Observations suggest that E40 is too warm during day time

Spring budgets 7

## Runoff April

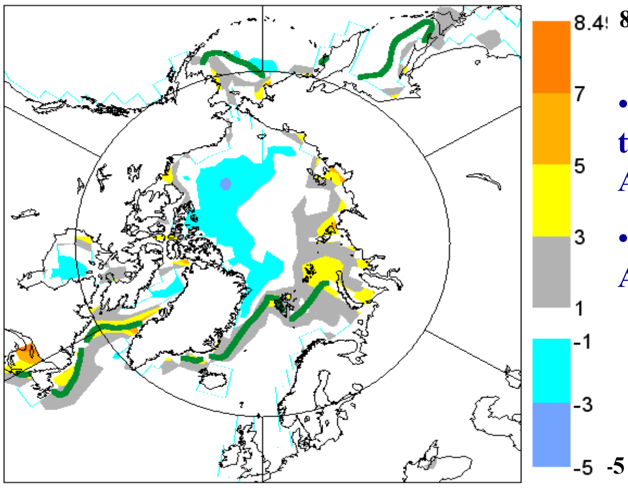
### E40 – E15




•Earlier snowmelt in E40, due to higher temperatures

•Most of the meltwater goes into runoff, due to reduced infiltrability of underlying soils

Spring budgets 8



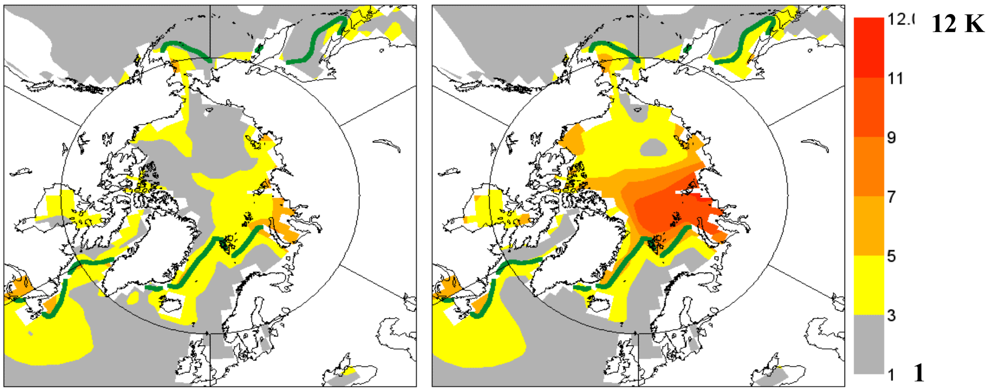

•Slightly colder temperatures in West Arctic basin (albedo ?)

•Slightly warmer in East Arctic

Sea ice 1

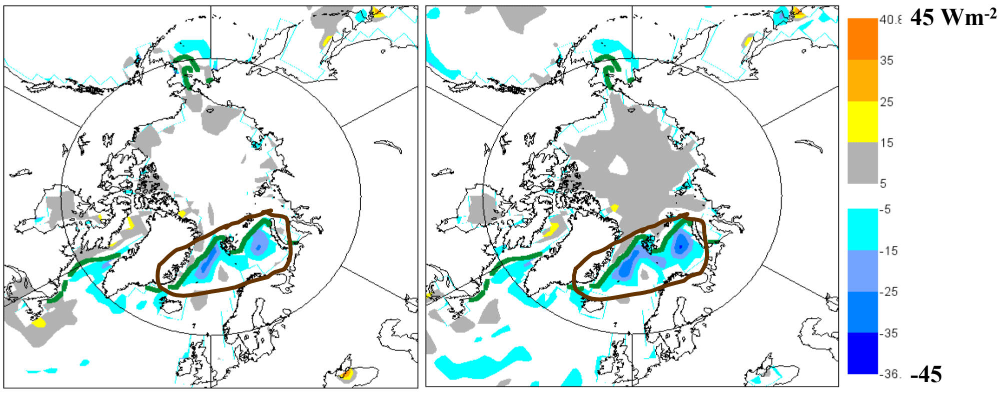
## Standard deviation of two-metre temperature March

E15 E40




•Much increased standard deviation of temperature, associated with a larger diurnal cycle (and faster response to synoptic fluctuations) due to multi-layer ice

Sea ice 2




•Increased fluxes in the marginal ice zone, due to fractional ice cover

Sea ice 3

## Conclusions (1)

- **Winter**
  - **E15 cold bias removed (soil freezing, snow albedo); A much smaller warm bias dominates E40.**
  - **E40 soils moister than E15 (reduced drainage).**
  - **Snow analysis improved in E40 (more observations; better usage of observations; better climate; use of model information as background). Large changes in data distribution remain.**
- **Summer**
  - **Improved soil water analysis in E40: Drier soils, larger sensible heat flux, smaller latent heat flux. Larger amplitude of seasonal cycle of soil water.**
- **Spring**
  - **Higher surface air temperatures in E40: Much smaller albedo of snow covered forests, combined with a reduction in transpiration.**
  - **First hint of physical realism in surface runoff in E40: A peak associated to snow melt over frozen soils.**

- **Sea ice**
  - **Increased variability in March surface temperatures (multi-layer model).**
  - **Increased fluxes in the marginal ice zone associated with fractional snow cover.**