EVOLUTION OF PERMANENT SURFACE WATER ICE AT HIGH NORTH LATITUDES

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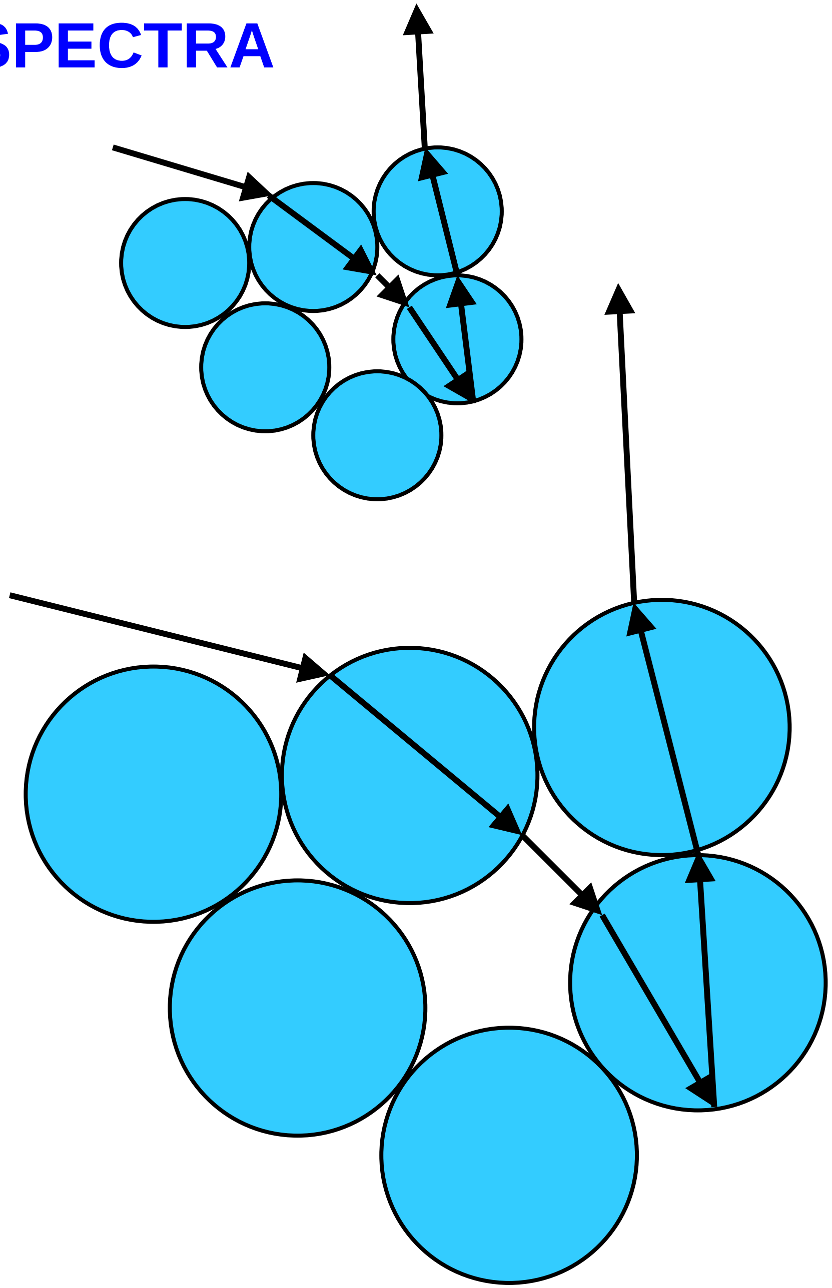
- OMEGA provides a unique capability to study surface ices:
  - strong signatures of H_2O and CO_2 between 1 and 5 µm (see next two talks)
  - S/N > 300 from 1.1 to 2.6 µm (four major and minor water ice bands)
  - spatial resolution (IFOV) of 1.2 mrad

- Orbital evolution and season provided a major window of opportunity from the solar conjunction (09/2004, close to the northern summer solstice) to end of January 2005 (light levels drop as the fall equinox gets closer)

- During this period, the pericenter moved North by ~ 70°
  The altitude over the pole decreased from 4000 km (5 km pixel size) to 600 km (< 1 km pixel size)

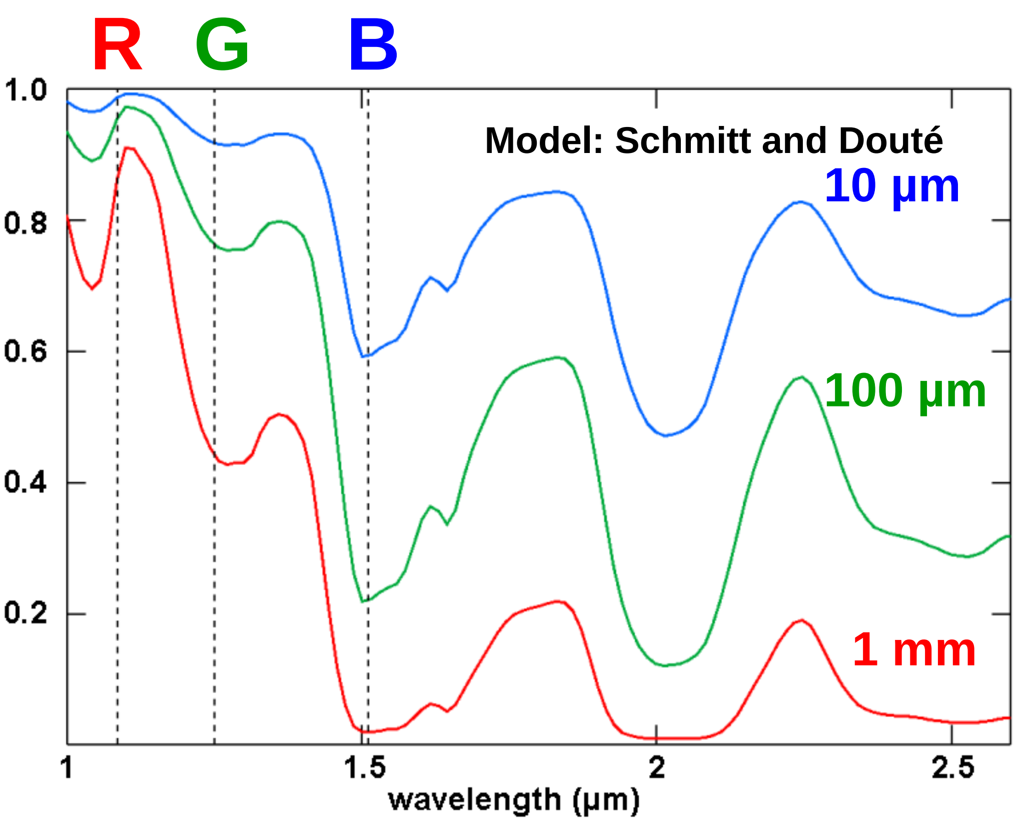
- OMEGA obtained nearly global maps of high latitude northern regions at resolutions of 3 to 5 km in the first two months of summer, then higher resolution observations.

PURE H_2O ICE REFLECTANCE SPECTRA



Strong dependence on grain size

Scattering at interfaces is unchanged, but the lenght of the path within ice increases with size → saturated bands

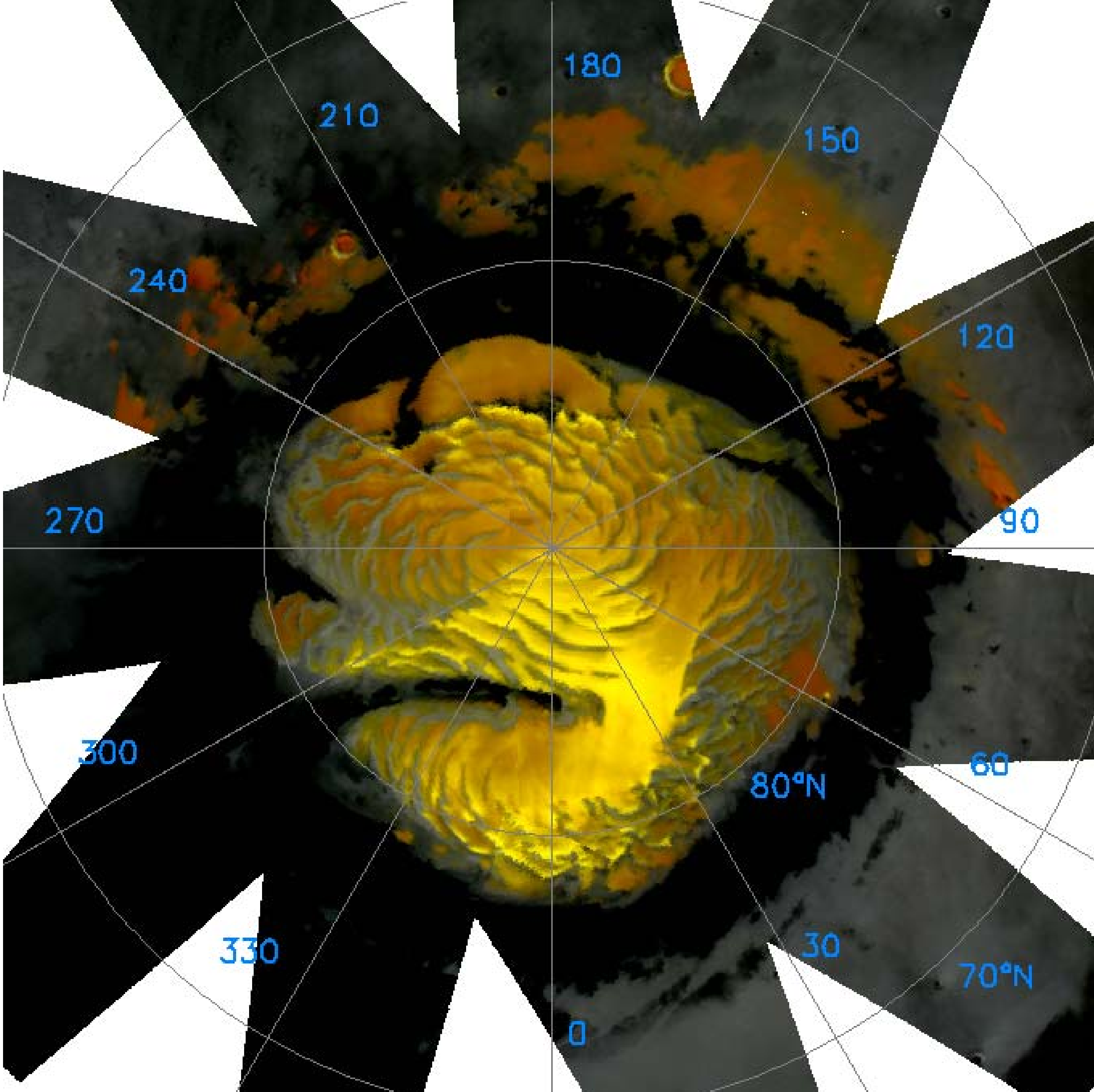


Ls 93° to 98°

most of the central regions are **dominated by small grains (< 100 µm)**

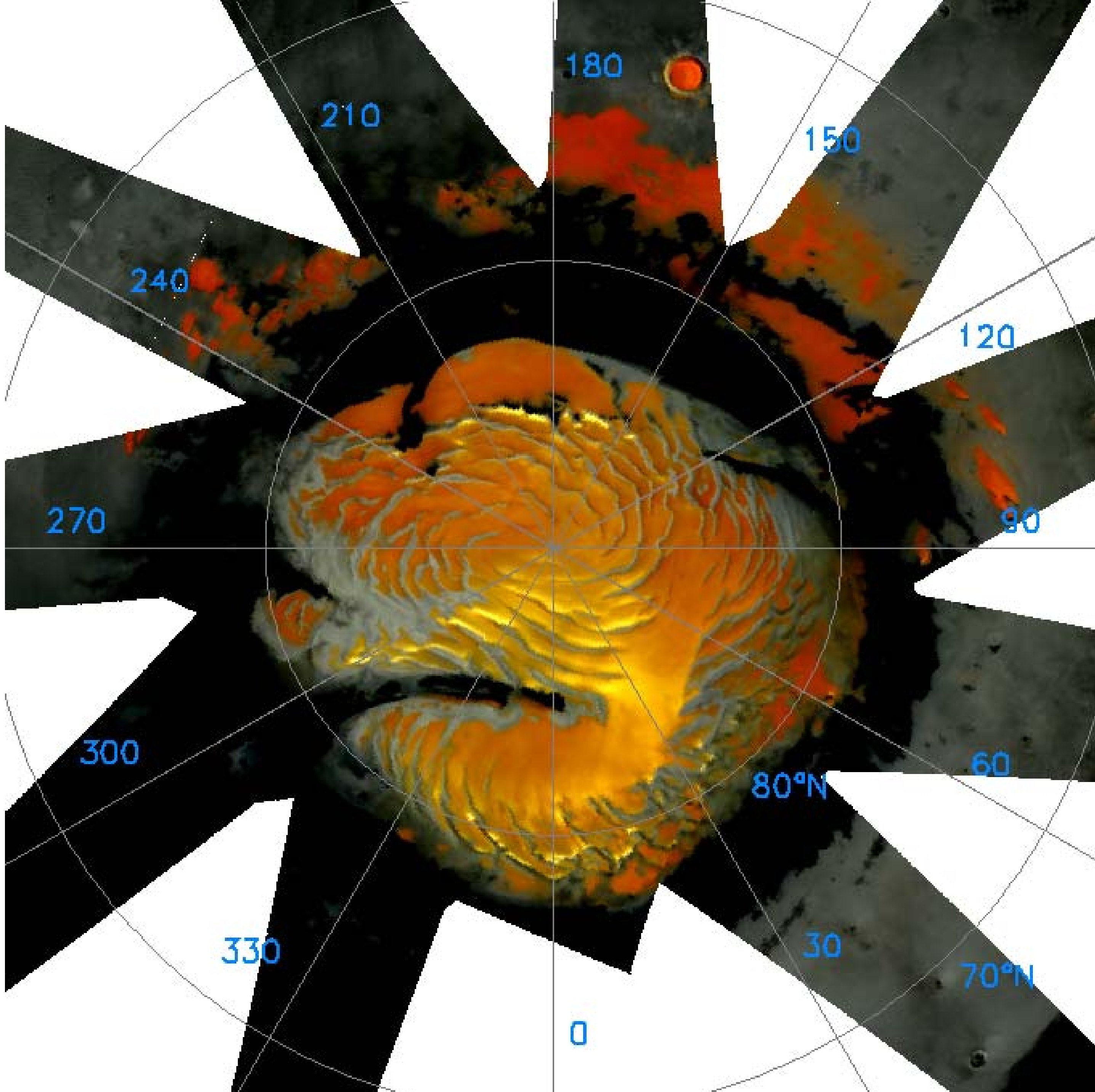
surviving seasonal frost ?

outer regions have larger grain sizes (~ 1 mm) **low albedo contrast in the continuum**



Ls 101° to 104°
(two weeks later)

small grained water ice (< 100 µm) loses ground



outer regions get brighter

The distribution of surface ice (red to yellow) is very similar to albedo contrasts from Viking (1976)

Ls 107.4° to110°

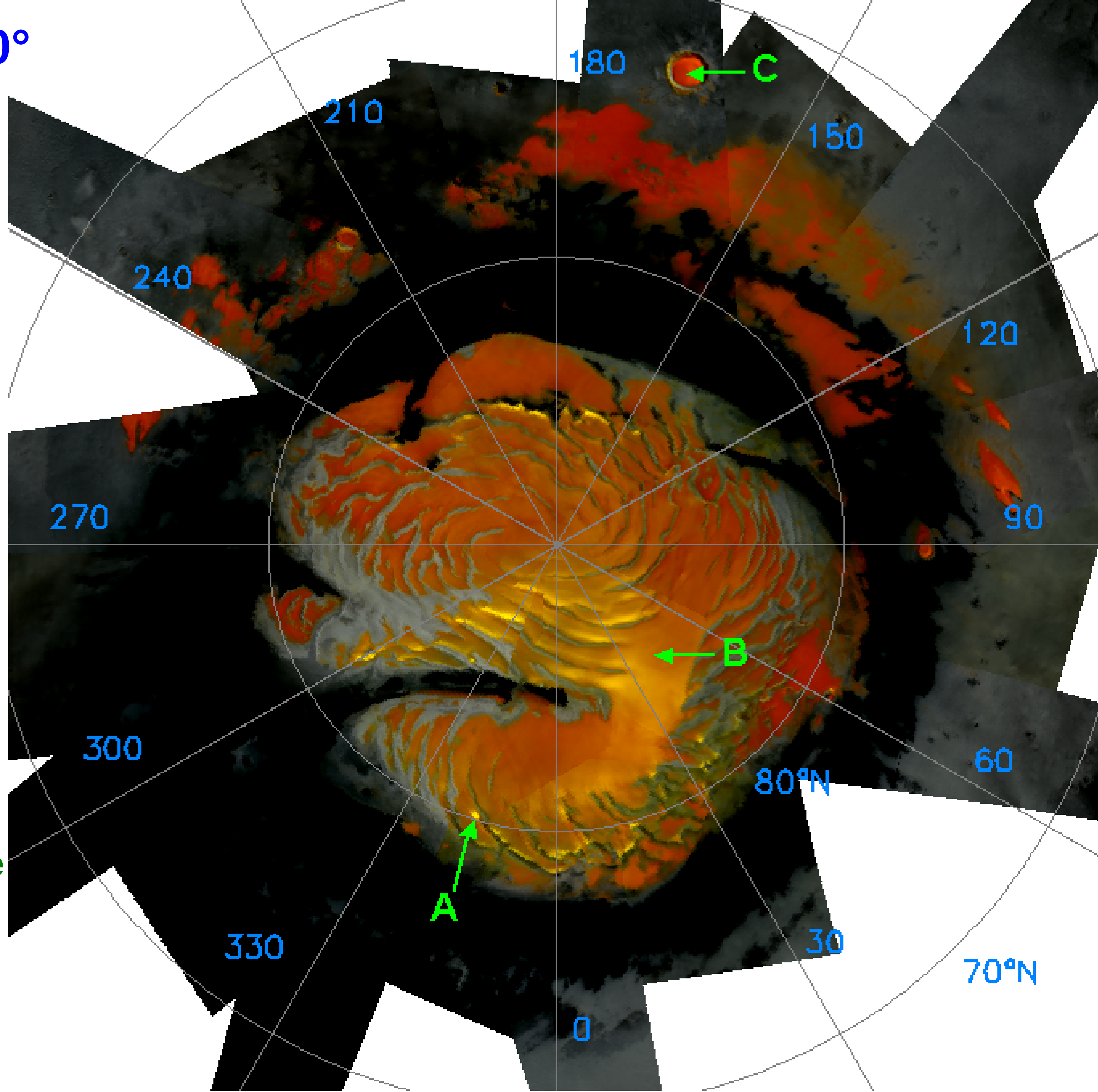
(one month later)

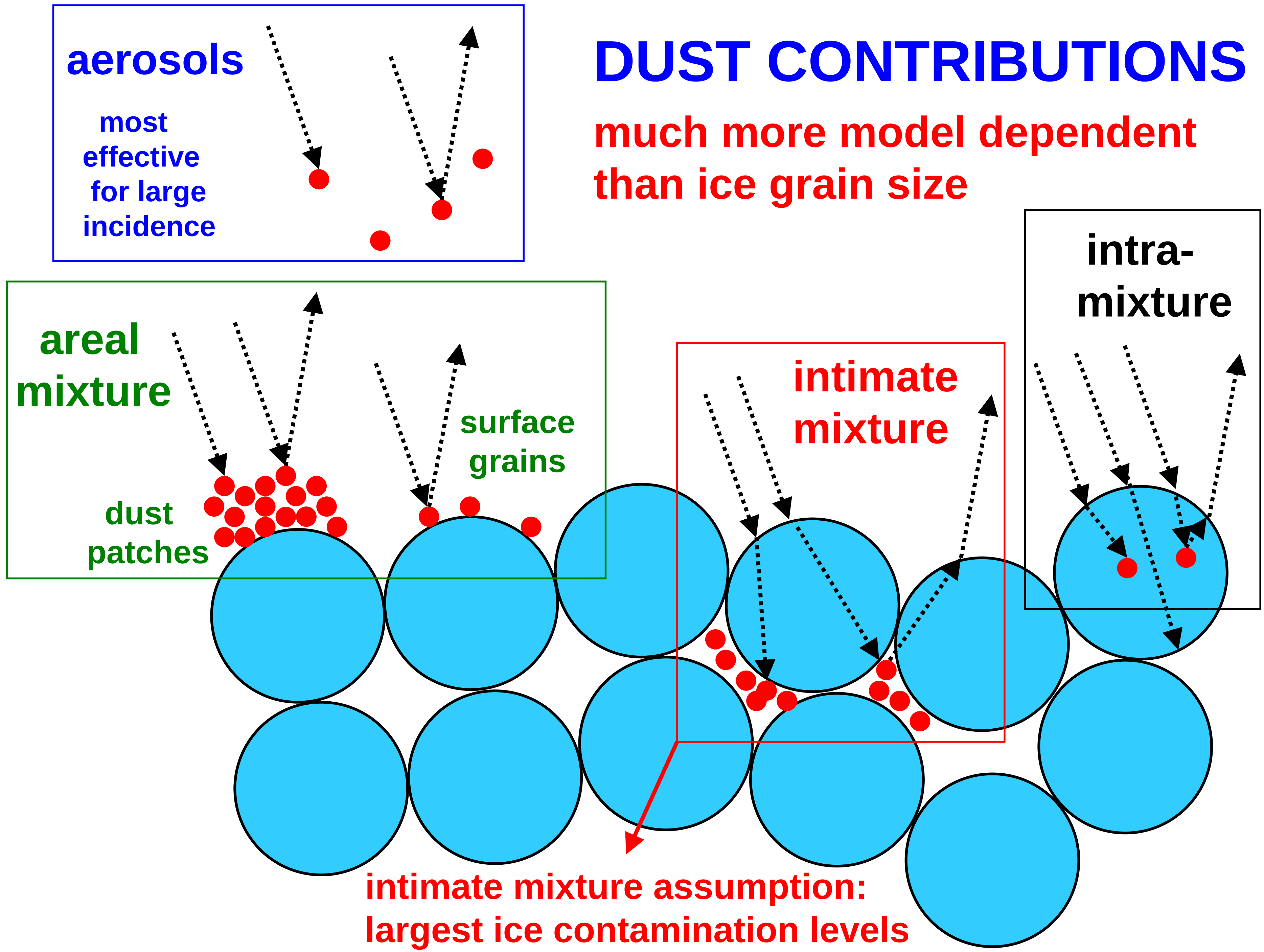
no major evolution of the areal distribution of surface ice

only a few patches of small grained ice survive (region A) « snow drifts » ?

Regions of interest have been defined so as to follow spectral evolution:

A: small-grained ice
B: central cap
C: Korolev




DUST CONTRIBUTIONS
much more model dependent
than ice grain size
aerosols
most
effective
for large
incidence
areal
mixture
surface
grains
dust
patches
intimate
mixture
intra-
mixture
intimate mixture assumption:
largest ice contamination levels

Region A (343° E, 80.2° N) :
little evolution over 70 days

radiative transfer model results:
80% small ice grains (< 50 μm)
17.5% ice grains (50 to 200 μm)
2.5 % dark dust (5 μm)
(upper limit: intimate mixture)

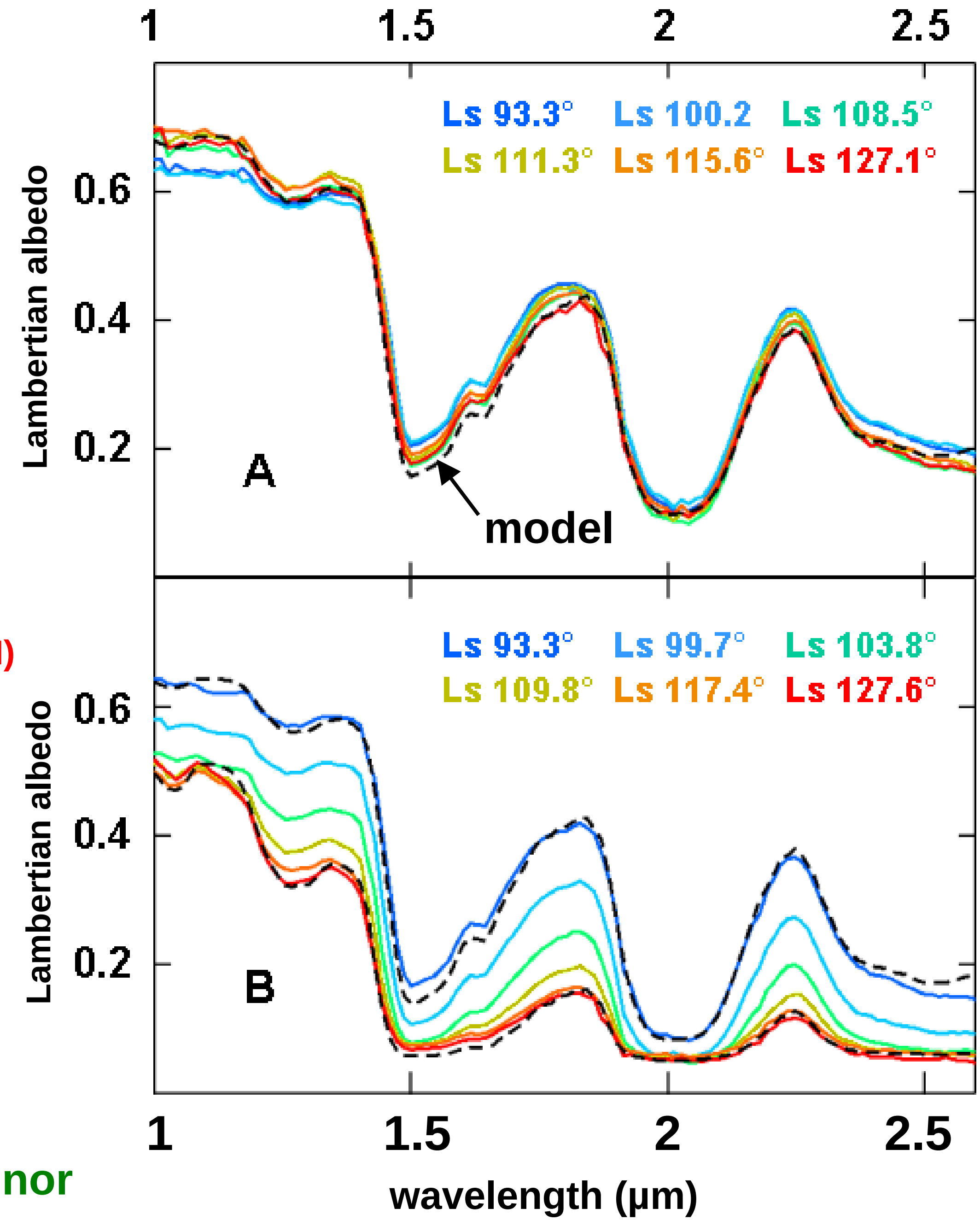
Long term survival of small-grained ice: thick « snow drift » ?

Region B: central cap (42.5° E, 85° N)

Ls 93.3° : similar to region A

Ls 127.6° : large-grained ice
5% dark dust (5 μm)
25% small ice grains (< 50 μm)
70% large ice grains (700 to 800 μm)

sublimation of surface frost, exposing old, large-grained ice
dust contamination is at most minor

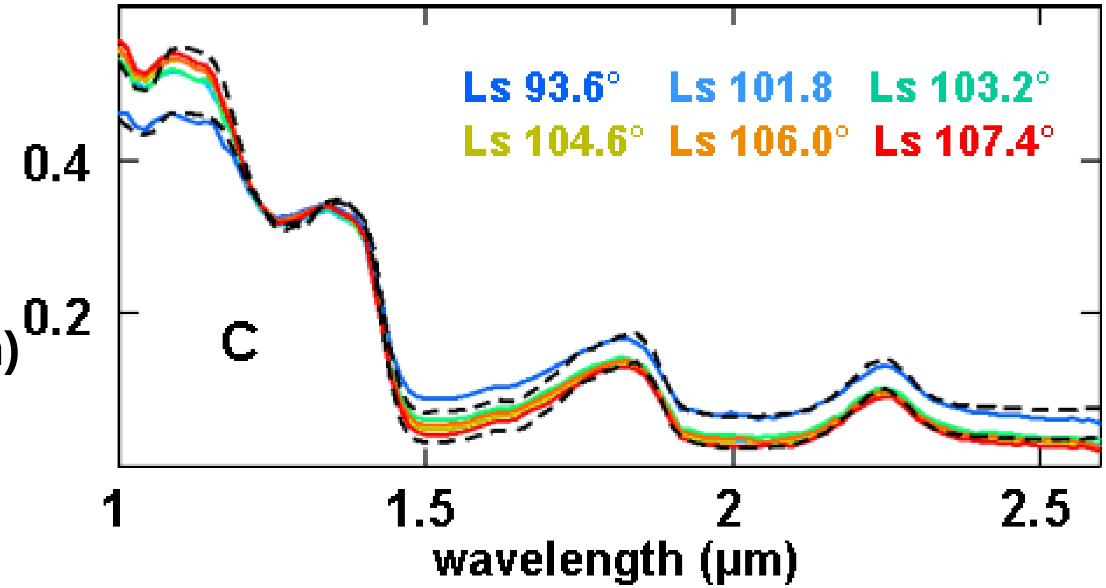


EVOLUTION OF WATER ICE WITHIN CRATER KOROLEV

large outlying ice-filled crater, 164° E, 72.4° N

dominated by large grains since Ls 93.6°
(70% ice grains ~ 800 µm)

upper limit of dust content (intimate mixture assumption) decreases from 10% to 5% over one month



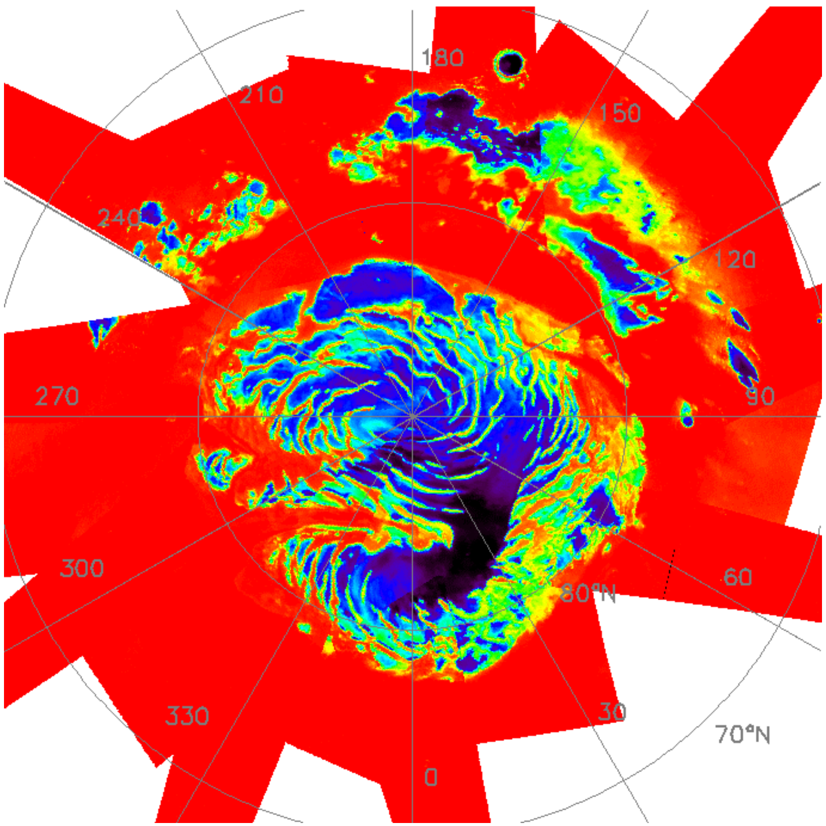
- typical evolution for outlying regions: initial low albedo contrast in the continuum (brightest dusty regions: also 45% albedo)
  albedo contrasts in the visible are not reliable for mapping surface ice

- Increase of albedo, contrast of ice bands between Ls 93.6° and Ls 107°
  → clean-up process linked to sublimation
  (alternate: global aerosol cover from 70° N to 80° N, getting thinner with time)

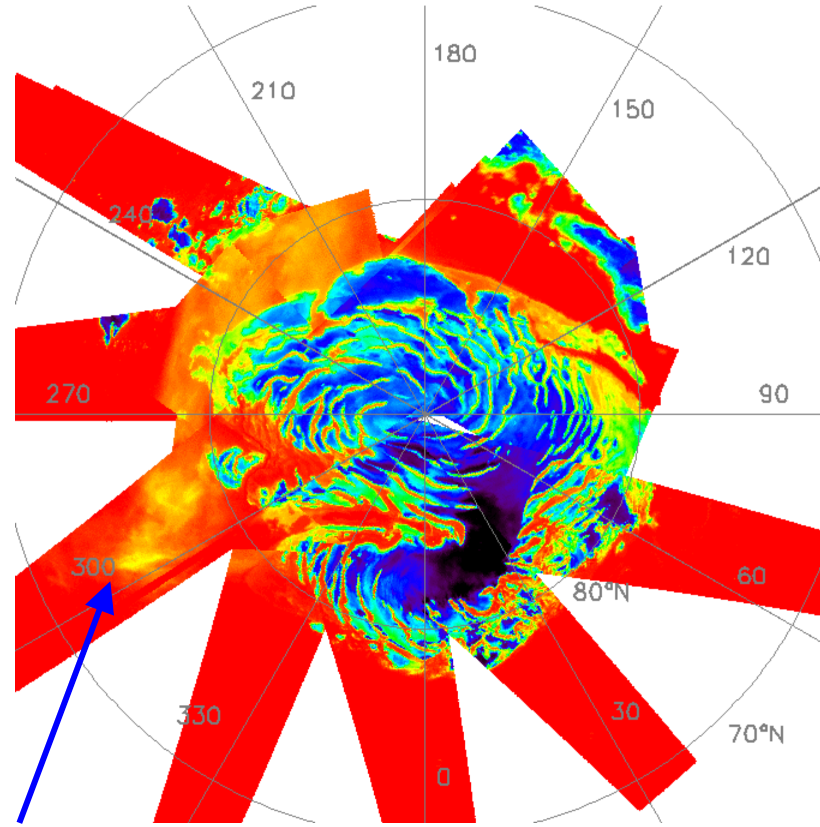
- reflectance at 2 µm is only 2% at the end. Most likely very clean old ice, (taking into account possible areal or intra-mixture dust contamination)

ONSET OF WATER ICE CLOUD ACTIVITY

Ls 107.4° to 110°



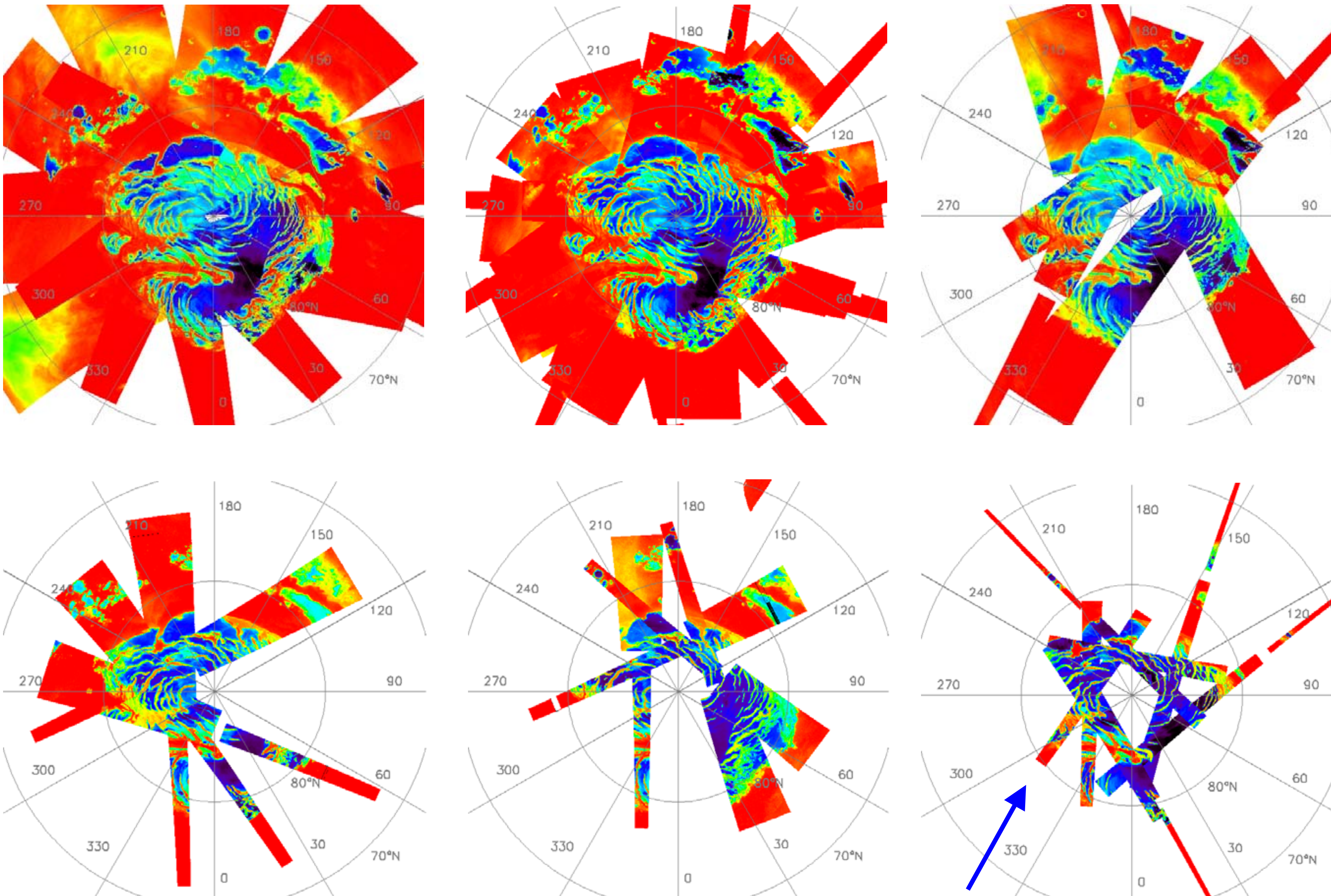
Ls 112° to 115°



Transient weak water ice signature:
ice-rich clouds

(presentation by B. Gondet on Wednesday)

Ls 115° to 145° : ice clouds + changes in surface ice properties



no evidence for frost formation on circumpolar dust deposits

CONCLUSIONS

- OMEGA directly maps surface water ice

  Seasonal or year to year changes reported on the basis of albedo in the visible have to be considered with caution.

- major changes in albedo observed after the summer solstice (Ls 93° to 145°) result from two competing processes:

  - in central regions, the sublimation of a bright, small-grained surface layer (< 100 µm) exposes larger-grained « old ice » (~ 1 mm) with a lower albedo

  - in outlying regions, a clean-up process lowers the dust contribution from aeral, intimate or intra mixing (possibly also due to a change in aerosol optical thickness).

- the extent of surface ice is stable over 4 months,

  even if minor changes are observed at the fringes, in particular after Ls 115°, which corresponds to the onset of ice cloud activity

- up to Ls 145°, there is no evidence for frost formation on dusty areas

  It may occur preferentially on the colder ice-rich areas

DUST CONTRIBUTION

much more model dependent than grain size

several contributions:

- **aerosols**
  - lower light level on the surface: lower apparent albedo
  - backscattering contribution: lower spectral contrast of ice bands
- **areal mixture:** sub-pixel dust patches or isolated dust grains on the surface
  - linear combination of ice spectrum and dust spectrum
  - lower albedo, lower spectral contrast of ice bands
- **intimate mixture:** dust grains mixed with pure ice grains
  - different scattering properties at grain interfaces
  - lower albedo, lower spectral contrast of ice bands
- **intra-mixture:** small dust grains within large ice grains
  - photons can be absorbed or scattered before reaching ice grains interfaces. Very effective process for lowering the albedo
  - extreme example: dust grains within a thick slab of water ice
  - same scattering properties (and albedo) as pure dust in the continuum