

ACCORD-AROME

aerosol studies

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From Sahara to Helsinki

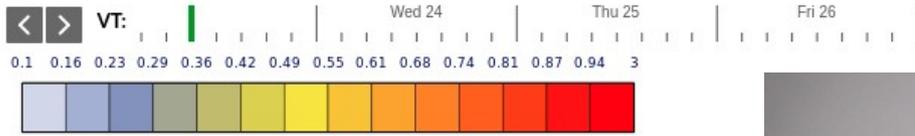
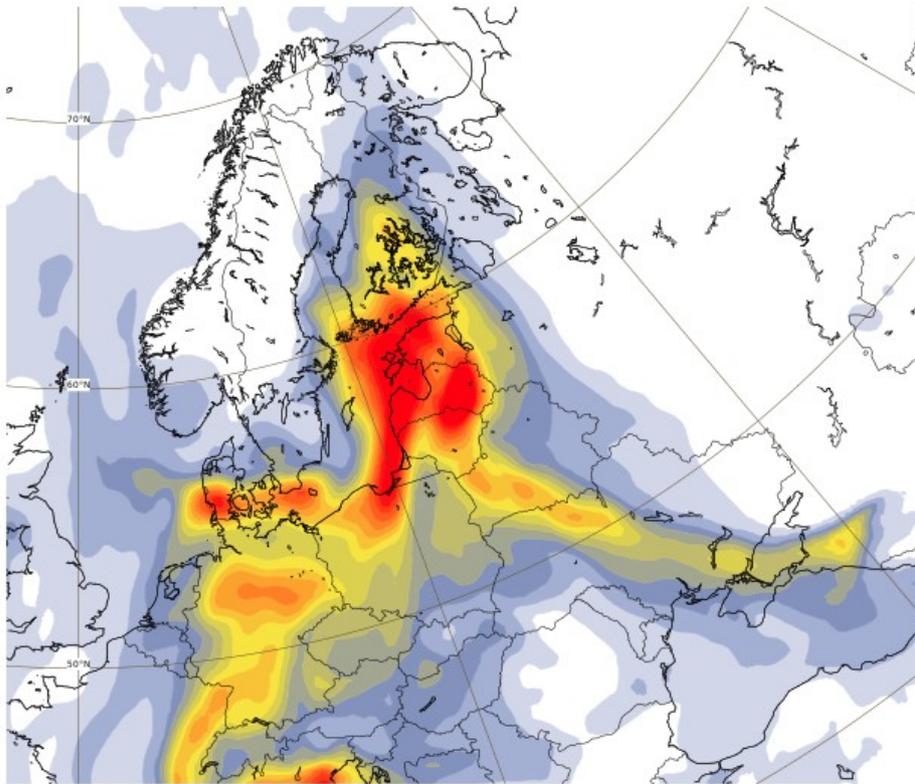


20210225 15UTC melting snow on sea ice, Helsinki

20210223 09UTC

Base time: Tue 23 ... Area: North East E... Aerosol type: Total ...

Aerosol optical depth at 550 nm (provided by CAMS, the Copernicus Atmosphere Monitoring Service)
Tuesday 23 Feb, 00 UTC T+9 Valid: Tuesday 23 Feb, 09 UTC



Aerosol optical depth at 550 nm (provided by CAMS, the Copernicus Atmosphere Monitoring Service)
CAMS aerosol forecasts

Precipitation Type, , at 09Z Tue 23 Feb
MEPS mbr0: 2021022306+3h0min, cy40h1.1, 2.5 km



20°E 30°E 50°N



Aerosol MMRs for cloud microphysics parametrizations



Helsingin Sanomat maanantaina 1.3.2021 ■ 9
KOTIMAA

Saharan hiekkaa pyydettiin lähettämään tutkimukseen

Sää | Hiekkaa tarvitaan kymmeniä grammoja jäädytyskokeita varten.

"Sitteen nähdään, että kun tynyistä hiukkasta pisteitään sinne, missä lämmössä ja kosteudessa syntyy jääkkeitä." Jos ne ovat tehokkaita jäädyttäjiä, jäät muodostuu Laakson mukaan jo silloin, kun suhteellinen ilmakeitos on juuri ja juuri sellainen, että jäätä voisi ylipäänsä muodostua. Laakson mukaan tällä hetkellä ymmärretään yllättävänkin huonosti sitä, millaisia hiukkasia 5-15 kilometrin korkeuksissa on ja mikä niistä ovat tehokkaita ytimiä jääkkeitä.

SAHARASTA tulee tuulen mukana harvoin hiekkaa Suomeen, mutta nyt ajoitus oli erinomainen. Ilmatieteen laitoksella on Laakson mukaan syksyllä alkamassa tutkimusprojekti, jossa juuri tämänkaltaisia asioita tutkitaan. Toinen projekti on pariaikaa käynnissä. "Tähän sattui nyt vähän tällainen onnenkantamoinen, että juuri sellaista tavaraa tuli tänne, mistä olemme kiinnostuneet." Vaikka hiekkaa ei saataisi kerättyä tarpeeksi jäädyntökoetta varten, saatuja näytteitä tutkitaan esimerkiksi mikroskoopin ja muilla menetelmillä. Niistä joitakin tuloksia saadaan julki ehkä jo tulevina viikkoina. "Nämä jäädyntökokeet vievät pidempään, mutta jos tavaraa tulee tarpeeksi, joitakin tuloksia meillä on parin kuukauden ajankänteellä. Jos tulokset ovat kelvollisia, ne julkaistaan jossain vaiheessa tieteellisessä kirjallisuudessa. Siihen mene suurin piirtein vuosi", Laakson sanoo. Keräyskehuksista kertoi aiemmin Aamulehti.

io Pellinen STT

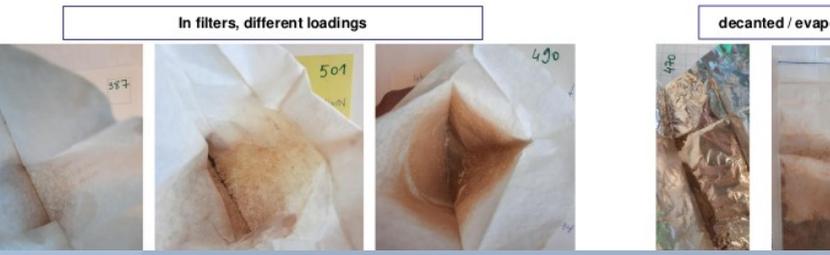
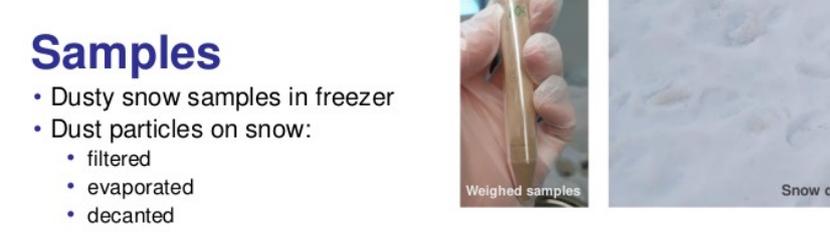
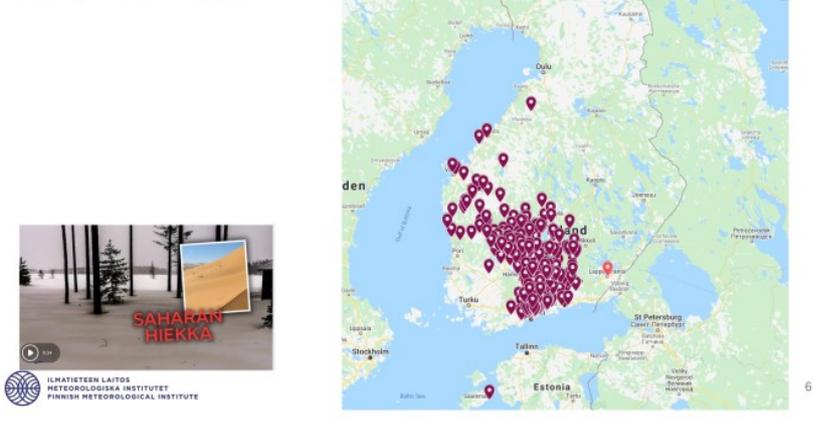
KIN Jonkin verran näytteitä on hiekasta saapu postitieteen laitokselle alkuvuonna. Hiekkaa tarvitaan ilmiä yläpintaan eli cirrus-sittilevää tutkimusta varten. Ilmatieteen laitoksen tutkijalla Ari Laaksonen. Hän on lauantaina Twitterillä suodattamaan luista viime tistään ja paikkailta tullutta hietämää sitä laadunottoja oli sunnuntaiin mennessä. Posti alkaa a vasta viikon...

...otetaan yli seitsemän... korkeuteen, maadostavate ne tehokkaasti näiden yläpölyjen jääkkeitä ympärilleen. Koska jos muodostavat, sillä on merkitystä siihen, millaisia niiden pölyjen ilmastolliset ominaisuudet ovat maapölylle saapuvan auringonvalon kannalta", Laaksonen kertoo.

Poiminta
Näin keräämiseen voi osallistua

- Kerää läikkien värjäämää pintalunta ruokalusikalla noin 2 desilitraa sulata ja suodatta lumi huoneenlämmössä kahvin suodatinpaperin läpi. Lumen voi myös sulattaa toisessa astiassa ja kaataa veden suodattimeen. Kääri kuivunut suodatin folioon tai muovipussiin.
- Suodattamisen sijaan voit myös antaa 1 desilitran lunta...

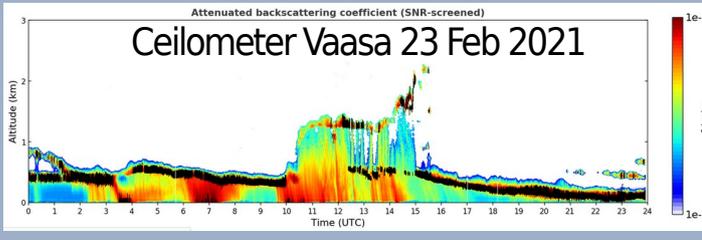
525 citizen samples of Saharan dust deposition



Courtesy of outi.meinander@fmi.fi

FMI requested people to collect a cup of snow with Saharan dust, filter it by a coffee filter and send to researchers for analysis and to be studied in nucleation chamber. They got 525 citizen samples. Studies are ongoing.

This case is interesting from the point of view of cloud microphysics parametrizations. Unfortunately, it was too cloudy and too little SW radiation to estimate accurately the aerosol optical depth based on radiation measurements.



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RELOCATING DUCKS



Tegen aerosol since 2004

- * 2D monthly global climatology of land, sea, urban, desert aerosol optical depth at 550 nm (AOD550)

- * Used for radiation only

- * Combined with hard-coded aerosol inherent optical properties to obtain AOD, SSA and asymmetry factor as a function of 6 SW + 6 LW wavelengths (with fixed humidity)

Tegen, I., Hoorig, P., Chin, M., Fung, I., Jacob, D., and Penner, J.: Contribution of different aerosol species to the global aerosol extinction optical thickness: Estimates from model results, *J. Geophys. Res.*, 102, 23895–23915, 1997.

Aerosol forecasts

Filters

Show All

Family

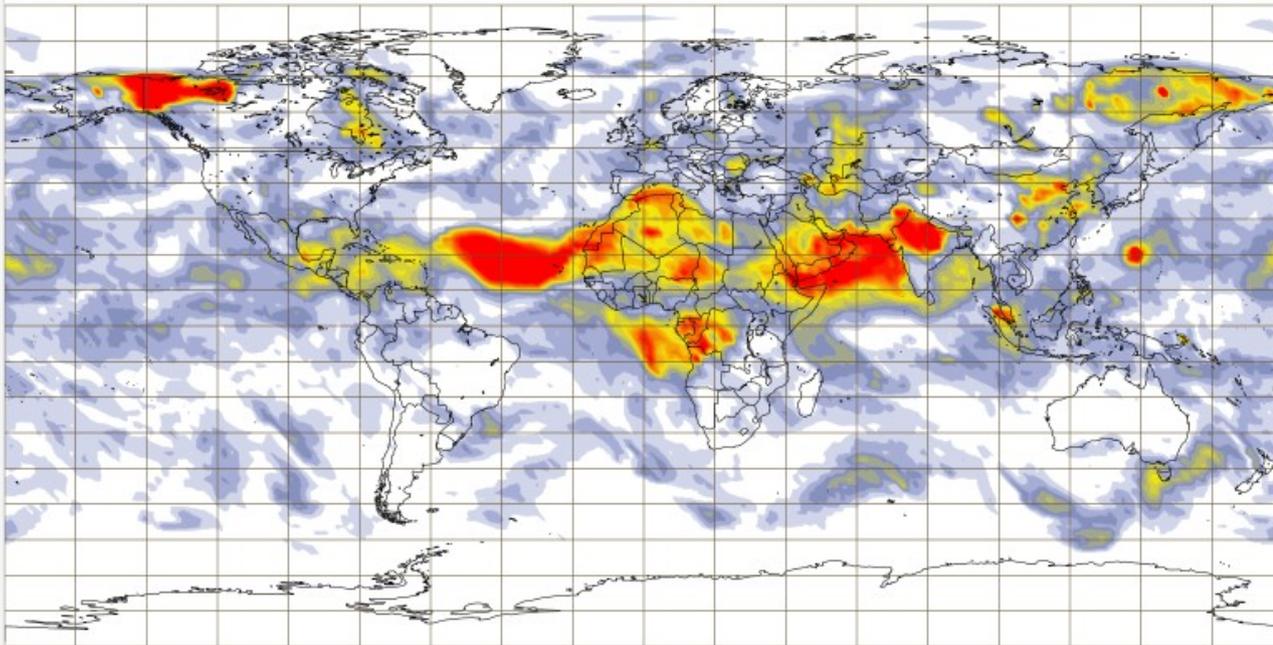
Aerosols (2)

[show 4 more](#)

Base time Area Aerosol type

Filter results

Aerosol optical depth at 550 nm (provided by CAMS, the Copernicus Atmosphere Monitoring Service)
Sunday 8 Jul, 00 UTC T+3 Valid: Sunday 8 Jul, 03 UTC



Aerosol data available from CAMS

Climatology and
Near-real-time
3D or 2D integrated

Mass mixing ratio
(x,y,z)

Inherent optical
properties:
mass extinction, single
scattering albedo,
asymmetry factor as
functions of
wavelength, humidity
and aerosol species

CAMS aerosol usage in ACCORD climatology and/or n.r.t. comparison

Climatology

resolution 2.5 deg

clim
developing

2D integrated

MMR

(x,y,z) for 11 species

IOPs

ME, SSA, ASY
(14+16 λ , RH, 11 species)

Radiation (and clouds)

Made in climate generation

Near-real-time

resolution 0.5 deg

n.r.t.
developing

3D and 2D integrated

MMR

(x,y,z) for 14 species

IOPs

ME, SSA, ASY
(14+16 λ , RH, 14 species)

Radiation (and clouds)

Imported via boundaries

RELOCATING DUCKS

Aerosol MMRs for cloud microphysics parametrizations



HARMONIE-AROME
with ICE3 microphysics



Meteo France-AROME
with LIMA microphysics

CAMS real-time 3D mass mixing ratio of aerosol in HARMONIE-AROME

Aerosol Mass mixing ratios are advected by the dynamics of the model

Aerosol removal processes are parametrized.

Aerosol Mass mixing ratios → Nuclei concentration → Activated nuclei (CCN)

Activated nuclei are used in the default microphysics scheme (ICE3):

Autoconversion (Kogan)

Cloud droplet sedimentation

Collision of cloud liquid

Aerosol mass mixing ratios are converted to optical depth@550nm
and used directly by the radiation schemes of the model.

(Aerosol inherent optical properties for different wavelengths
are prescribed by the ECMWF)

CAMS real-time 3D mass mixing ratio of aerosol in HARMONIE-AROME

Accumulated rain 17Feb20

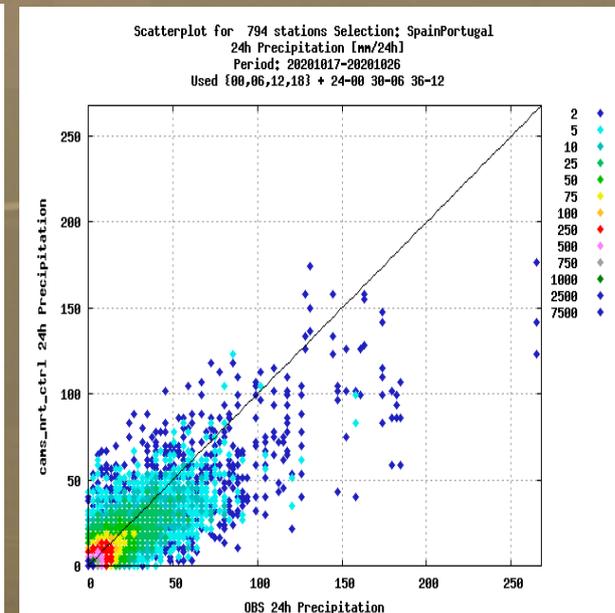
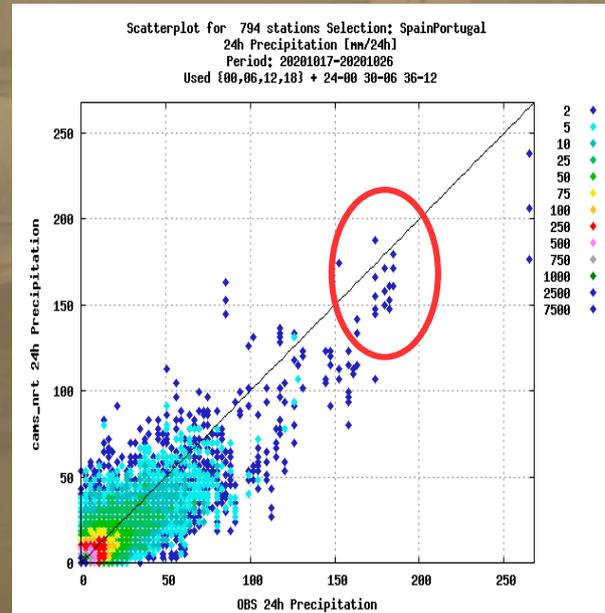
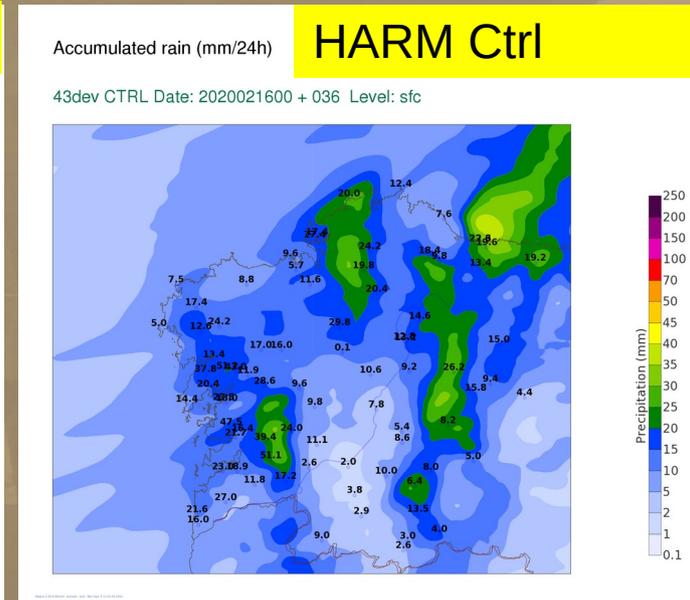
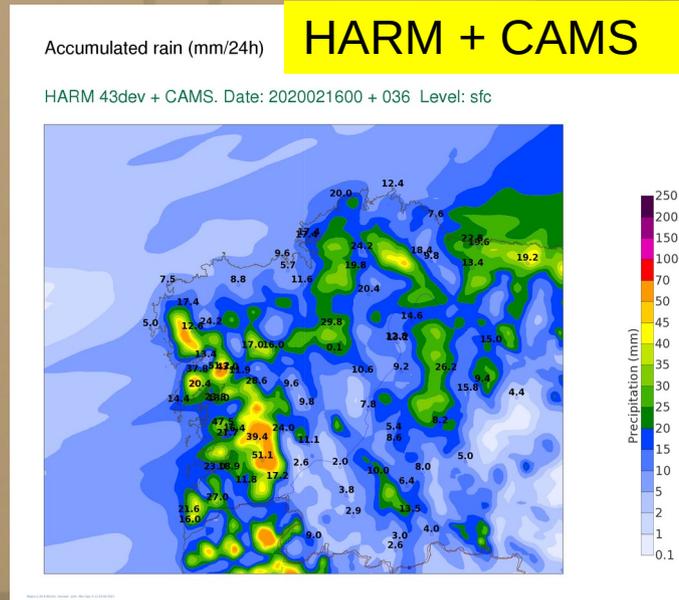
Impact on Precipitation.

In general the CCN number concentration is lower than the default values of the model.

Increase of the precipitation when nrt aerosols are used.

Specially important in high precipitation events.

Scatterplot
24h Precipitation
Period 20201017-20201026

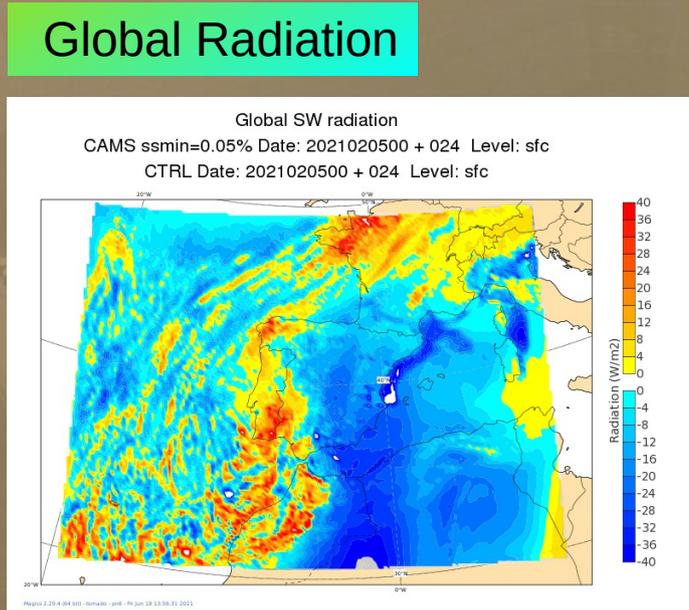
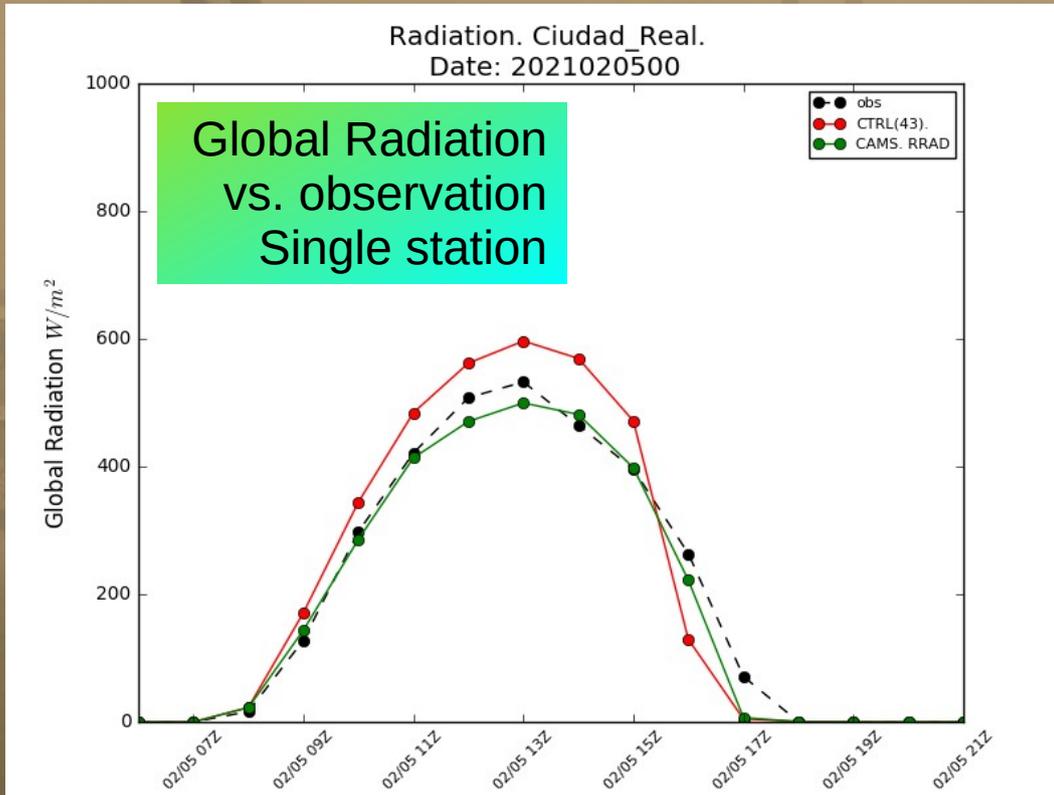
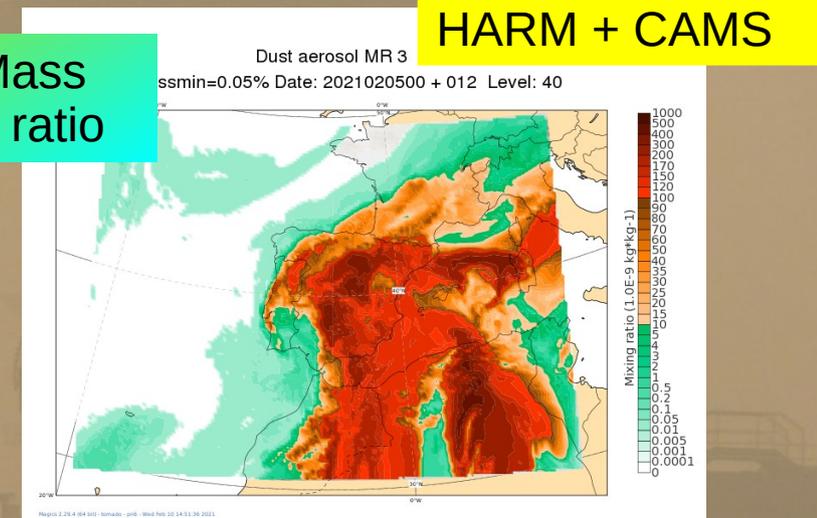


CAMS real-time 3D mass mixing ratio of aerosol in HARMONIE-AROME

Impact on Radiation

The use of nrt aerosols permit a better SW radiation forecast during dust events.

Case:20210205



(HARM + CAMS) – (HARM ctrl)

CAMS real-time 3D mass mixing ratio of aerosol in HARMONIE-AROME

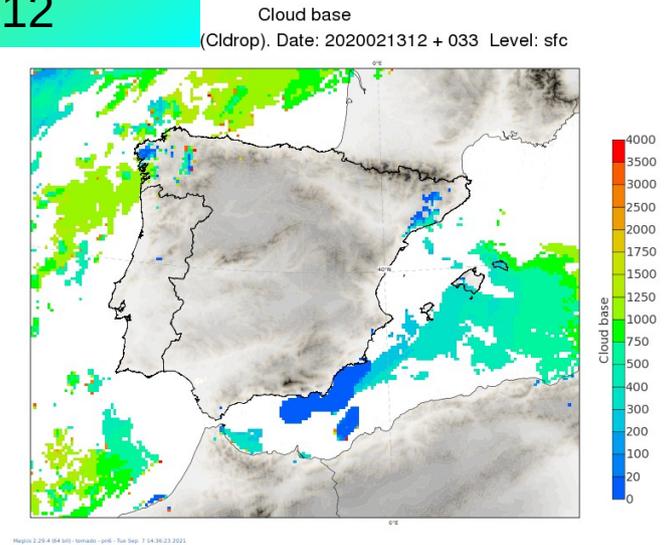
Impact on fog

The use of CAMS aerosols often have a positive impact on fogs, especially when the cloud droplet concentration is lower than by model default.

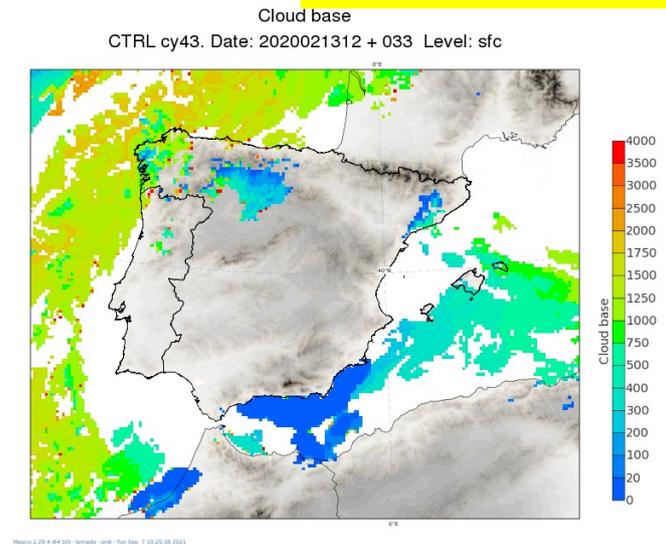
It also reduces the anomalous fogs that sometimes appear over sea. (Although this problem might be related with a wrong cloud droplet distribution in these cases)

HARM + CAMS

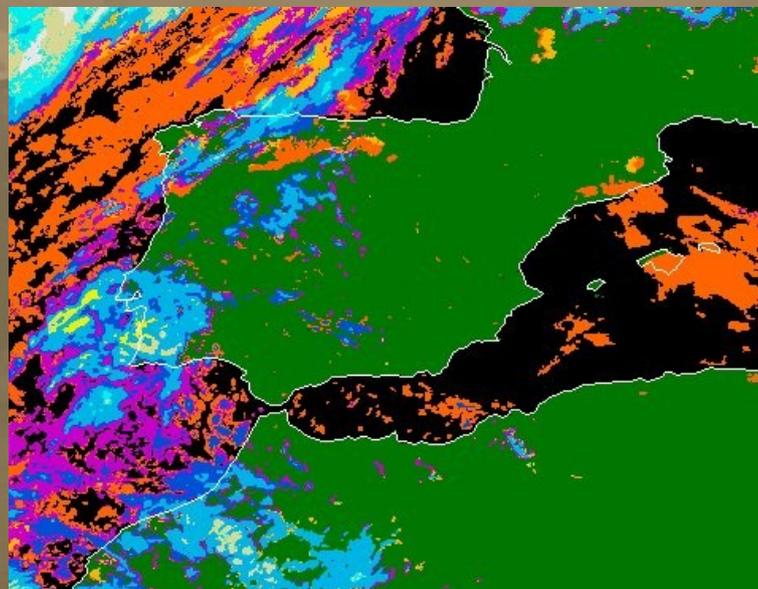
Cloud base height
2020021312



HARM Ctrl



SAFNWC
Cloud type
(Satellite)



Aerosol MMRs for cloud microphysics parametrizations



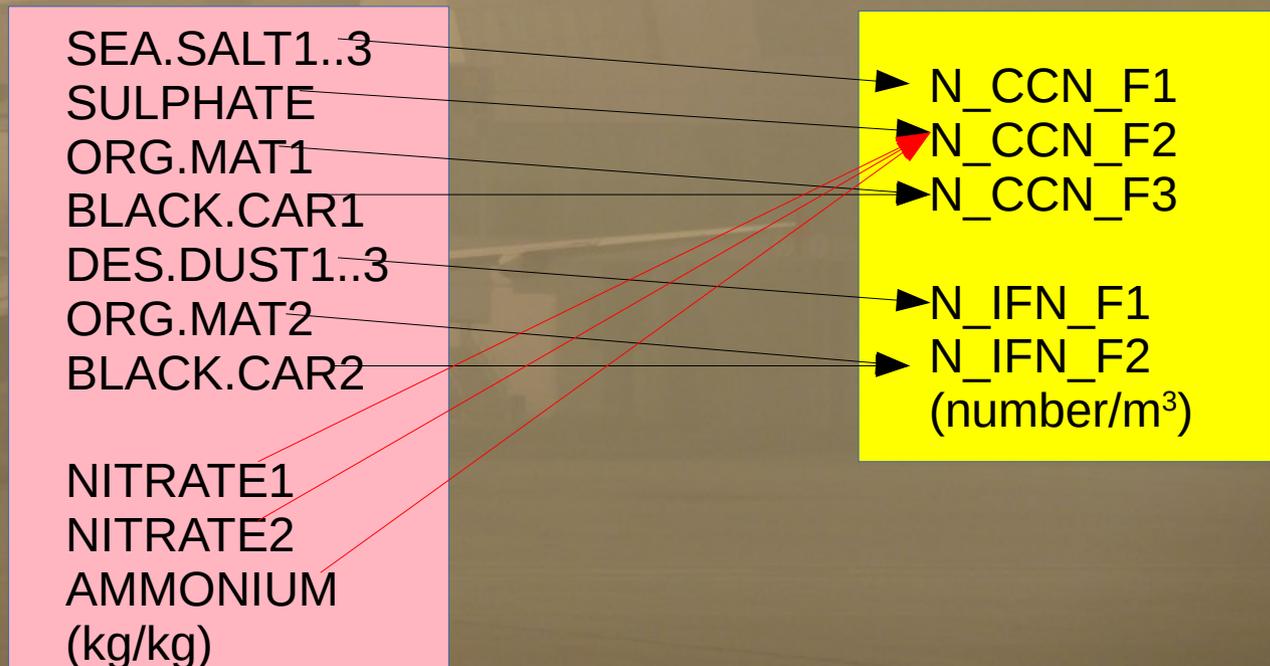
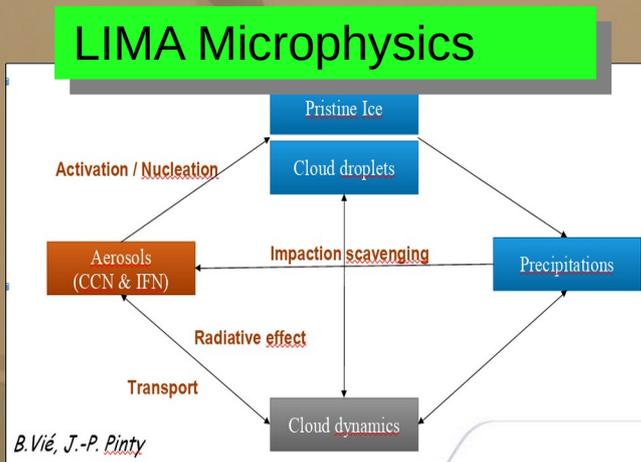
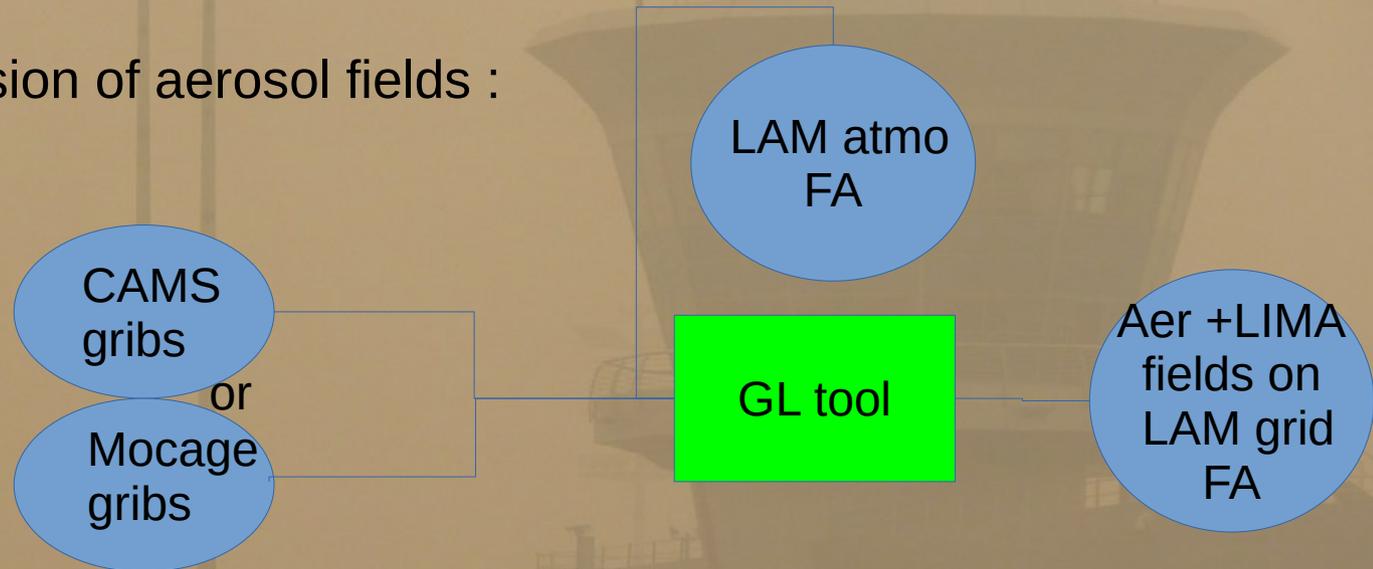
HARMONIE-AROME
with ICE3 microphysics



Meteo France-AROME
with LIMA microphysics

Links between aerosols and 2-moment microphysics

→ Preparation and conversion of aerosol fields :



A convective case example (2021-03-12)

→ Test on AROME-Algeria domain (M. Mokhtari) :

Precipitation
(ech 18h)

Base: 12/MAR/21 03z
Valid: 12/MAR/21 18z

Precipitation
(ech 18h)

Base: 12/MAR/21 03z
Valid: 12/MAR/21 18z

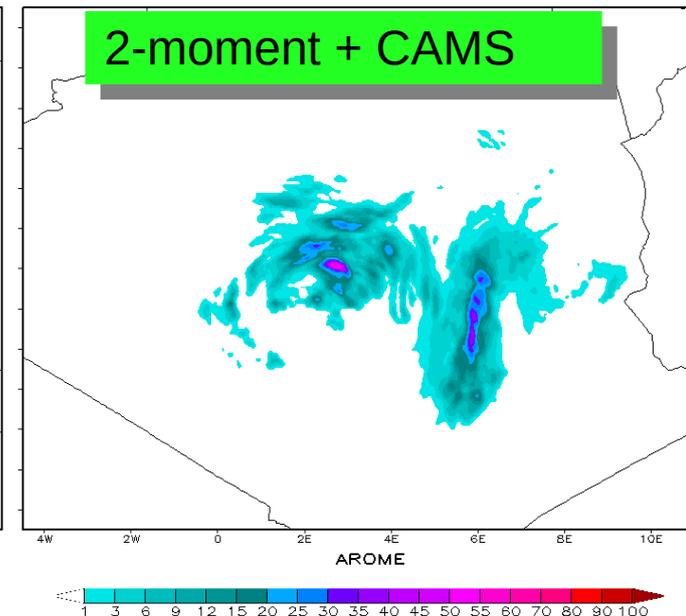
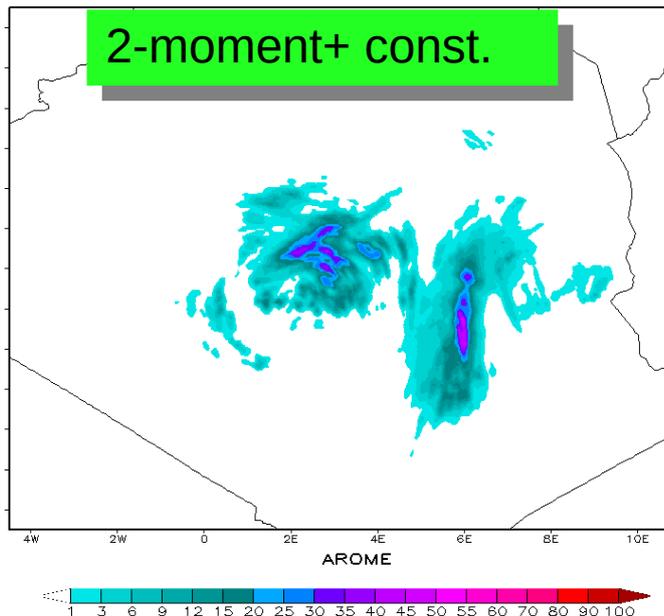
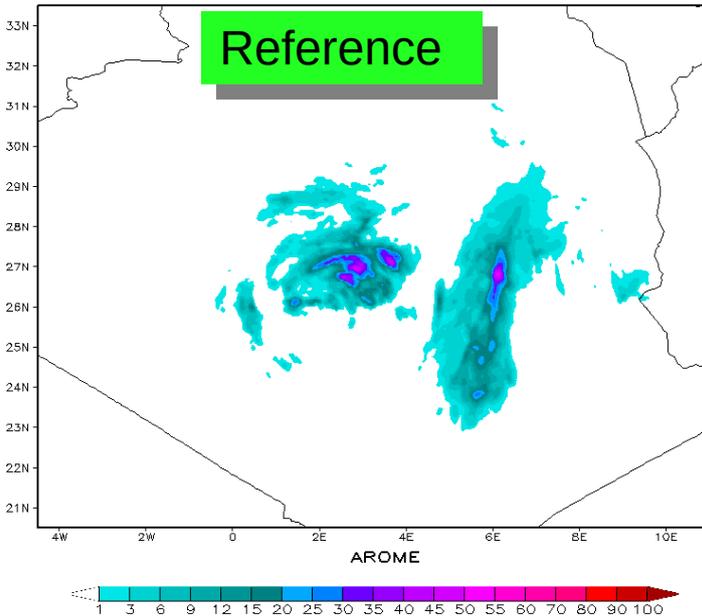
Precipitation
(ech 18h)

Base: 12/MAR/21 03z
Valid: 12/MAR/21 18z

Reference

2-moment+ const.

2-moment + CAMS



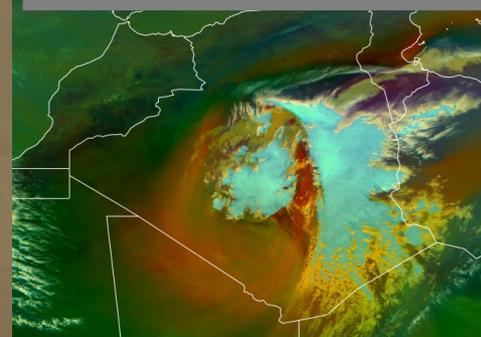
(1-moment microphysics)

(LIMA with aero constant initialisation)

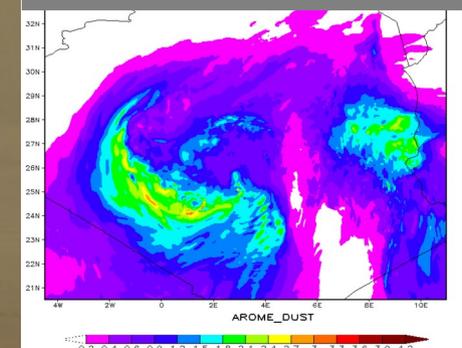
(LIMA with CAMS and AROME-Dust aero)

- more light rain with LIMA
- modified maxima
- to be evaluated on longer periods

Satellite Observation

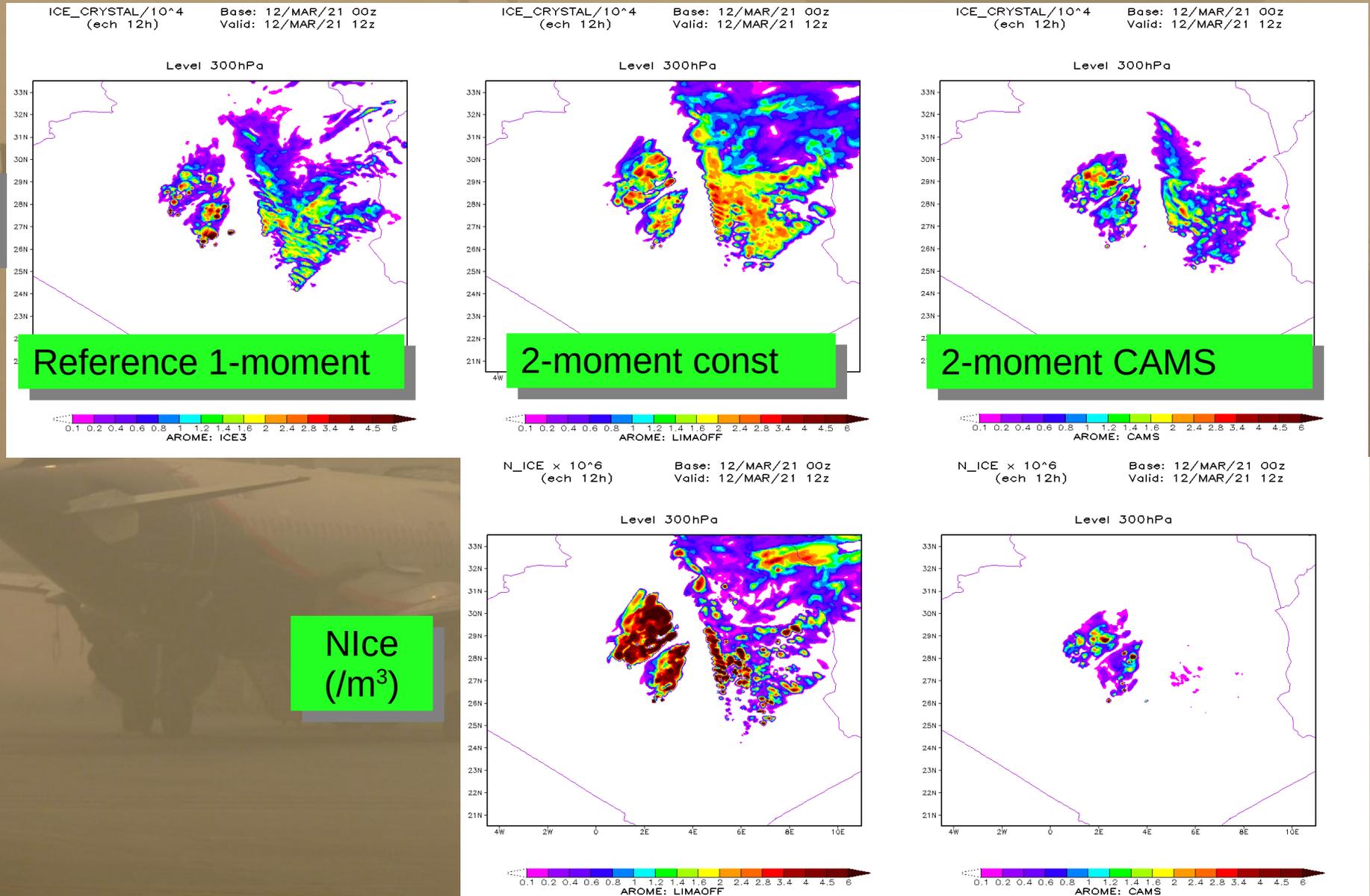


AROME-Dust AOD



A convective case example (2021-03-12)

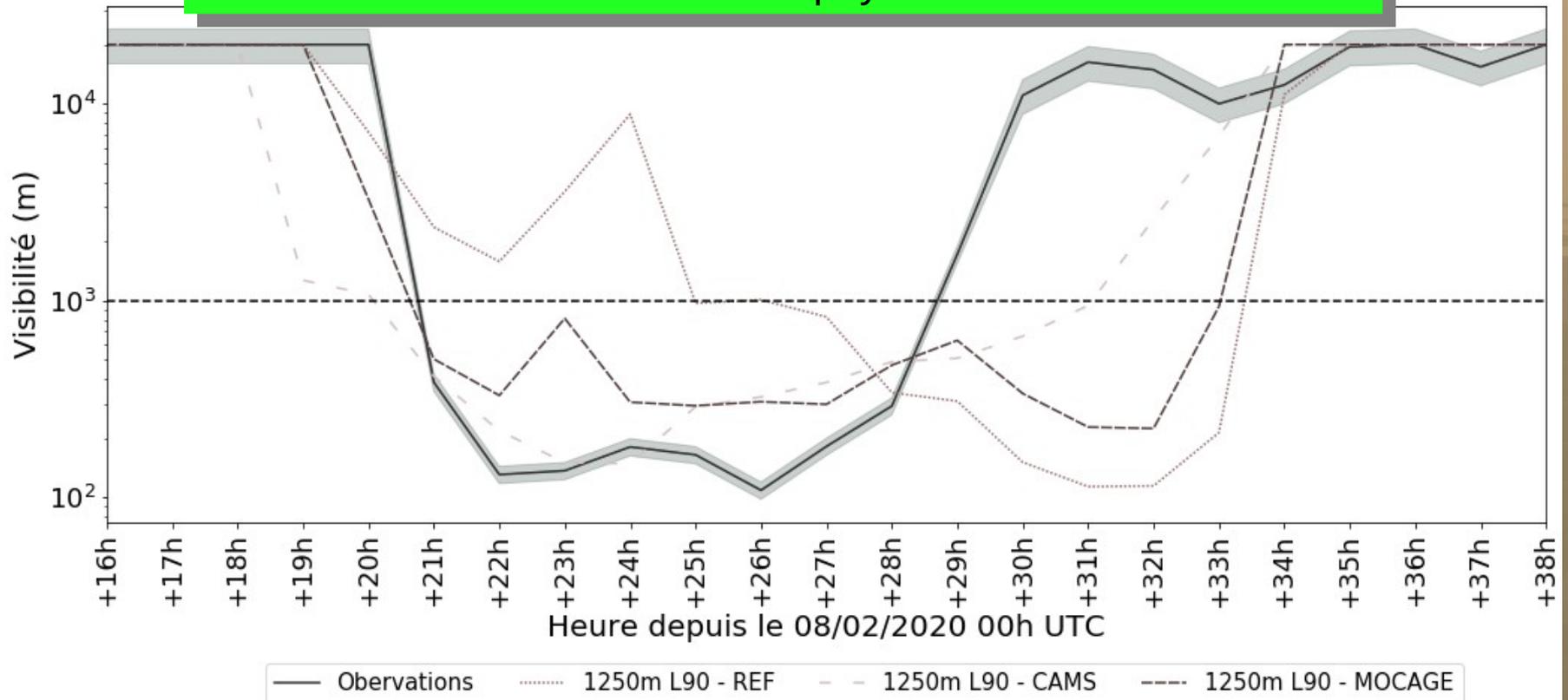
→ Differences in ice_crystals mass and number concentration:



A fog case example (2020-02-08)

Tests on AROME-SOFOG1250 domain (S. Antoine) in the SO of France :

Temporal evolution of visibility forecasts at SOFOG supersite AROME with LIMA microphysics / Observation



→ Improvements in the timing of the fog event

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Preliminary conclusions

Cloud, precipitation and fog evolution are sensitive to the atmospheric aerosol via cloud microphysics parametrizations (both liquid and ice phase)

Cloud droplet number concentration depends on aerosol concentration and influences both precipitation and, via cloud particle size, radiation transfer in clouds.

In clear-sky cases, the global SW radiation at the surface may reduce tens of W/m^2 due to direct radiation impact of aerosol

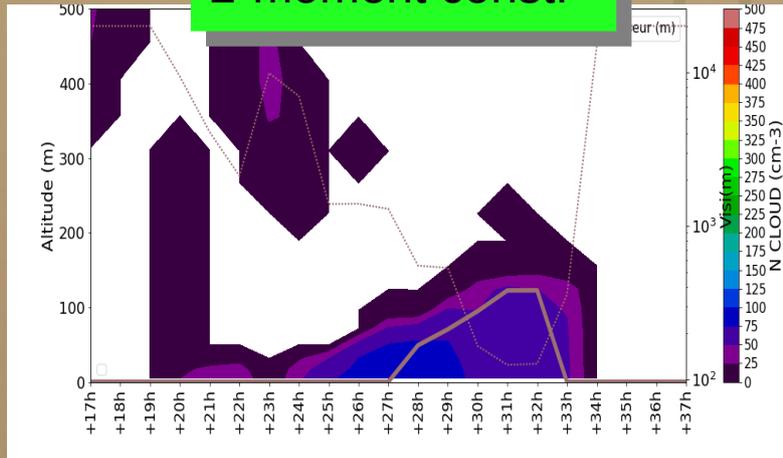
A close-up photograph of melting snow on sea ice. The snow is white and fluffy, with numerous small, irregular brown spots scattered across it. These spots are identified as Saharan dust. The background is a dark, textured surface, likely the sea ice.

THANK YOU - DISCUSSION, QUESTIONS!

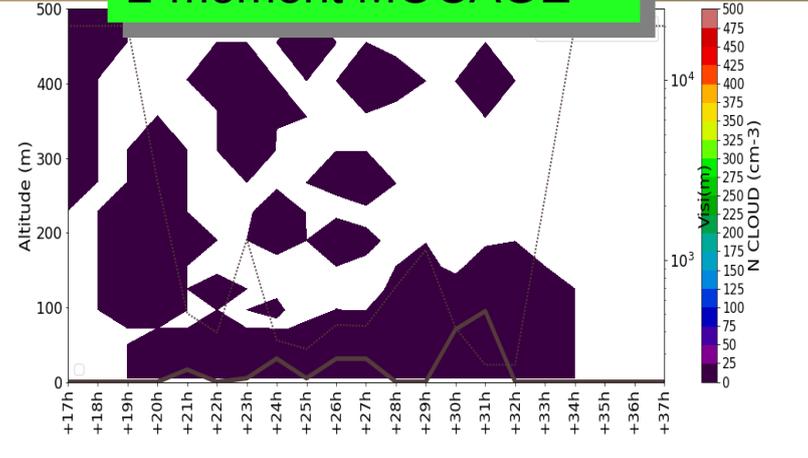
Saharan dust on melting snow on Helsinki sea ice 25.2.2021. Photo: Laura Rontu

A fog case example (2020-02-08): Cloud droplet number concentration

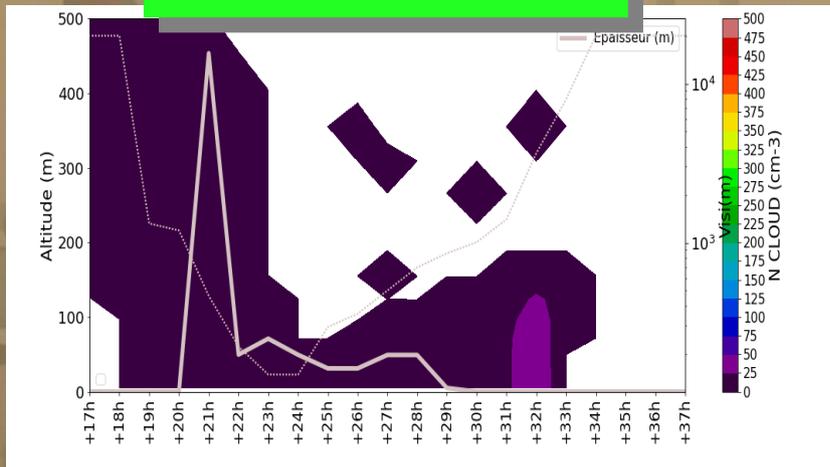
2-moment const.



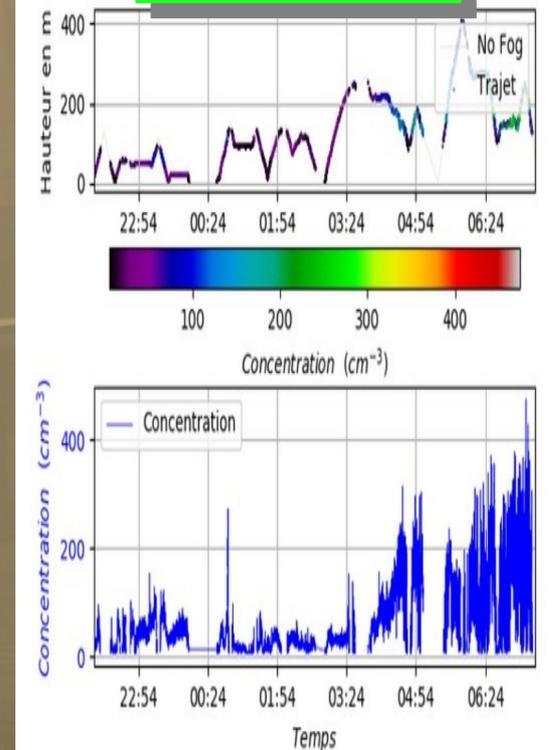
2-moment MOCAGE



2-moment CAMS



Observations



- More sensibility than in the convective rainfall case
- To be tested on longer periods

CAMS climatological or real-time 2D/3D mass mixing ratio of 11 aerosol categories

- !SS1,SS2,SS3,DD1,DD2,DD3,OM1,OM2,BC1,SU
- !CLSUF(1)='AEROMMR.SS1 ' Sea salt (RH, wavelength) size bin 1
- !CLSUF(2)='AEROMMR.SS2 ' (hydrophilic) size bin 2
- !CLSUF(3)='AEROMMR.SS3 ' size bin 3
- !CLSUF(4)='AEROMMR.DD1 ' Desert dust (two flavours, wavelength) size bin 1
- !CLSUF(5)='AEROMMR.DD2 ' (hydrophobic) size bin 2
- !CLSUF(5)='AEROMMR.DD3 ' size bin 3
- !CLSUF(7)='AEROMMR.OM1 ' Organic matter hydrophilic (RH, wavelength)
- !CLSUF(8)='AEROMMR.OM2 ' hydrophobic (wavelength)
- !CLSUF(9)='AEROMMR.BC1 ' Black Carbon hydrophilic (RH,wavelength)
- !CLSUF(10)='AEROMMR.BC2 ' hydrophobic (wavelength)
- !CLSUF(11)='AEROMMR.SUL ' Tropospheric sulphates (RH, wavelength) (hydrophilic)

based on C-IFS forecasts that include data assimilation

ALSO AVAILABLE:

SO2 precursor mixing ratio	aermr12
Volcanic ash aerosol mixing ratio	aermr13
Volcanic sulphate aerosol mixing ratio	aermr14
Volcanic SO2 precursor mixing ratio	aermr15

Aerosol optical properties prescribed by ECMWF

Assumptions for 11 aerosol species:

- Spherical particles
- Log-normal size number distribution
 - Prescribed refractive index and density of particles, depending on humidity

Mie scattering calculations →

Inherent optical properties of 11 aerosol types
for 14+16 RRTM wavelengths

ME mass extinction coefficient - $AOD = ME * MMR$
SSA single scattering albedo - scattering/absorption
ASY asymmetry factor - prevailing direction of scattering

Aerosol optics

Aerosol IOP* data available

SW [nm]	LW [μm]
3846 - 12195	28.57 - 1000.00
3077 - 3846	20.00 - 28.57
2500 - 3077	15.87 - 20.00
2151 - 2500	14.29 - 15.87
1942 - 2151	12.20 - 14.29
1626 - 1942	10.20 - 12.20
1299 - 1626	9.26 - 10.20
1242 - 1299	8.47 - 9.26
778 - 1242	7.19 - 8.47
625 - 778	6.76 - 7.19
442 - 625	5.56 - 6.76
345 - 442	4.81 - 5.56
263 - 345	4.44 - 4.81
200 - 263	4.20 - 4.44
	3.85 - 4.20
	3.08 - 3.85

Default radiation parametrizations in HARMONIE-AROME:

Solar radiation flux at 6 spectral intervals of IFS scheme

0.185 - 0.25 - 0.44 - 0.69 - 1.19 - 2.38 - 4.00 μm
 0 % 11 % 38 % 35 % 15 % 0.4 %

Terrestrial radiation flux is calculated at 16 spectral intervals of the RRTM (IFS) scheme - but presently only AOD of 6 LW bands is used

Broadband (1 SW + 1 LW band) IOP's needed for ACRANEB, HLRADIA

* IOP = inherent optical properties: mass extinction, asymmetry, single-scattering albedo