CLOUDNET - DRAFT DOCUMENT FOR DISCUSSION - OCT 2002
INITIAL ALGORITHM RECOMMENDATION
AND DRAFT TECHNOLOGY IMPLICATION PLAN.

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1. INTRODUCTION.
This draft document discusses:
a) Parameters required from the algorithm.
b) Suggested instrument specification for Cloud Remote Sensing (CRS) station.
c) Outline of possible algorithms.
See also accompanying summary sheet and table.

2. REQUIRED PARAMETERS.
Current Parameters held in models.
- Cloud fraction, LWC, IWC, re (prescribed), ice term vely, assumed overlap.
Parameters being developed/ in use.
- subgrid - pdf of total waer content, LWC, IWC, re and overlap.
Ice cloud - crystal type/orientation (i.e. albedo and asymm function)
Turbulence levels, general dynamics/motion.
Sampling for sub-grid pdf:
Grid box: 1hr long, approx 500m deep; sample 30secs and 50m gives >1000 'pixels'.

Suggest we need to detect:
Ice cloud: τ of 0.05 over a depth of 500m (changes flux 10 W m^{-2})
and with an IWP 1 g m^{-2} or IWC 10^{-3} g m^{-3}?
Water cloud - adiabatic τ =1 has LWP 7 g m^{-2} , 120m deep av LWC 0.06 g m^{-3}.
{Aerosols - τ = 0.05? for 500m depth? needed?}

3. SUGGESTED INSTRUMENT SPECIFICATION FOR CRS.
(WILL NEED TO DISTINGUISH WHICH ALGORITHMS ARE 'ADVANCED' AND USED TO VALIDATE 'SIMPLER' ALGORITHMS TO BE USED IN ANY FINAL OPERATIONAL SYSTEM.

3.1 LIDAR SPECIFICATION.
a) Sensitivity: if lidar ratio 20, τ = 0.05 per 500m is β= 2.5 10^{-6} $m^{-1}sr^{-1}$ (need better?)
(for 30 sec sample with 50m resolution - see secn 2)
b) Wavelength: 1µm, 0.53µm, 0.35µm?
(molecular return for calibn and direct τ, but cloud β simpler if no molecular?)
c) Calibration - need molecular return? (or use integrated β in Sc?)
d) Depolarisation - need for liquid/ice discrimin? (ice crystal type?)
e) Beamwidth - (How) narrow to avoid multiple scattering?
f) Vertical pointing - avoid specular reflection or exploit it?
g) Justify Extras:
Doppler? dual wavelength? High spectral resolution? Raman?

3.2 RADAR SPECIFICATION.

a) Sensitivity -40dBZ sees 'all' ice clouds with $\tau > 0.05$ km^{-1}.
Difficult to have Z low enough to detect all water clouds.

b) Frequency: 35GHz or 94GHz.
35Ghz better: no atten by low altitude LWP? No Mie scatt?

c) Calibration - 94GHz use rain?? 35GHz - difficult??

d) Doppler - need mean, width or full spectra? What spectral resolution?
Vertical pointing so measure term velocities + w. (+turb?)

e) Extras: Dual wavelength - for LWC and Ice size?
Polarisation - information at v incidence?

3.3 RADIOMETER SPECIFICATION.

See document on web by Simpson et al.
lwp accuracy 0.0017cm or 17 g m^{-2}
Useful constraint? Thin supercooled layers 10 g m^{-2} .
OK in mixed phase clouds? Techniques for iwp? No range info.

4. POSSIBLE ALGORITHMS

4.1 LIDAR ALONE.

a) On many occasions total extinction by low level water cloud.
Extrapolate properties from cloud base β profile? (with radiom lwp constraint?) .

b) β alone to iwc and τ profile difficult: i) lidar ratio? ii) atten correction unstable (calib) iii) multiple scattering in dense clouds.
BUT can use molecular on far side as direct meas of τ.

c) Depolarisation - liquid/ice discrimin. ice gives xl type aspect ratio?

4.2 RADAR ALONE.

a) Not see all liquid clouds. No LWC from liquid clouds (drizzle).

b) Z (and T) to IWC - error up to factor of two. Sub-grid IWC pdf.

c) Doppler - term velocity as f(IWC) - Matrosov: IWC, Do?

d) Turbulence from spectra (liquid and ice clouds?).

DUAL WAVELENGTH 35/94GHZ

a) LWC profile from dual frequency attenuation - need longish dwells.

b) Particle size from Z ratio (Rayl/Mie) then use Z(Rayl) for better IWC.

4.3 RADAR/LIDAR

a) Identify phase - and supercooled layers.

b) Identify both liquid and ice clouds - form cloud mask.

c) Water clouds - lidar base/radar cloud top - lwc from assumed profile.
Drizzle fluxes. Turbulence from Doppler radar.

d) Ice clouds - KNMI/Donovan; CETP Tinel. - IWC, re, deduce k (lidar ratio)
(compare/combine with dual wavelength radar + lidar depol:
exploit 'k' and redundancy for Xl type/orientation????).
What is the resolution of these retreivals?
Biases if only operate when no low level liquid cloud?

Level 1 data	*Cabauw*	*Chilbolton*	*Palaiseau*
Z35, V35, WIDTH35: 35 GHz radar	➨	➨	
Z94, V94, WIDTH94: 94 GHz radar		➨	➨
BETA, BASE: lidar ceilometer	➨	➨	➨
DR, MOLEC: 'real' lidar			➨
LWP: Microwave radiometers	➨	➨	
RAD: Broad-band radiation	➨	➨	➨
MODEL: Model fields	➨	➨	➨
RAIN: Rain gauge	➨	➨	➨

Algorithm	*Required input*	*Optional input*	*Level 2 output*	*Comments*
Liquid cloud properties				
Frish method (TUD)	**Z, LWP**	**BASE, MODEL?**	**LWC**	Not in drizzle?
Differential attenuation (UR/Gaussiat)	**Z35, Z94, MODEL**	**BASE**	**LWC**	Only Chilbolton
Radar/lidar synergy: drizzle (UR/O'Connor)	**Z, BETA**	**MODEL, WIDTH**	**LWC_d, D_d, LWF_d**	Only below cloud base
Ice cloud properties				
Radar/lidar synergy (KNMI/Donovan)	**Z,**	**MODEL**	**IWC, extinction, r_e, R'_{eff}**	
Radar/lidar synergy (CETP/Tinel)	**Z, BETA**	**MODEL**	**IWC, extinction, r_e**	
Z-T-IWC (UR/Brooks)	**Z, MODEL**		**IWC, extinction**	
Dual-wavelength radar (UR/Hogan)	**Z35, Z94**	**BETA?**	**IWC, D_0**	Only Chilbolton
Matrosov method (?)	**Z, V**		**IWC, D_0**	Used widely by ARM
General cloud properties				
Mask & classification (UR/Brooks?)	**Z, BETA, RAIN, MODEL**	**V, DR, LWP**	**cloud mask, classification (e.g. phase)**	
Turbulence (CETP/Bouniol)	**V, MODEL**		**dissipation rate**	**V** must be high resolution

- **Issues to resolve**

⦶ ***Certain processing will be common to many algorithms: can time and effort be reduced by making use of the same analysis?***

  - Most algorithms don't work in rain (e.g. radome attenuation): use rain gauge to screen out.
  - Algorithms need to decide which clouds their algorithms will work on: is a common classification required?
  - Ice retrievals affected by uncertain liquid water cloud attenuation beneath (particularly at 94 GHz): need to identify and reject. Alternatively use microwave radiometer LWP to correct for attenuation?
  - Radars should be corrected for gaseous attenuation: NetCDF data now available with gaseous attenuation versus height calculated from ECMWF model.

⦶ ***How are the level 2 products to be recorded? Suggestions:***

  - Use NetCDF and store parameters at same resolution as raw data.
  - Use radar resolution rather than lidar in radar/lidar algorithms (easier comparison of same product from two algorithms).
  - Use agreed variable names (iwc, lwc, re_ice, re_liquid, alpha_ice, alpha_liquid, D0_ice, lwc_drizzle, D0_drizzle, lwflux, iwflux, epsilon, re_ice_dash, classification) and attributes (on web site).
  - Use agreed representation of errors (iwc_error, re_ice_error) as described on web site.

⦶ ***Level 2 quality control***

  - Systematically compare the algorithms that produce the same parameter.
  - Allow for different versions of the level 2 data to be produced.
  - Release code (in Fortran/C/IDL/Matlab) for each algorithm?

⦶ ***How are the products to be averaged to compare with models?***

  - Can the same cloud fraction, gridbox-mean IWC etc., be used for each model, or must different averaging times & vertical resolutions be used?
  - Can models make use of gridbox variances of cloud properties and PDFs?

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