

CLAIMS

1. A computer-implemented method for modelling a surface temperature distribution of a surface of a built environment, the method comprising, using
5 at least one processor:
 obtaining input data comprising: a latitude and longitude of the surface;
 material parameters for one or more materials of the surface; geometrical
 data indicative of a subdivision of the surface into a plurality of surface
 patches, each surface patch having a surface normal; and weather data;
10 initialising a temperature of each surface patch; and
 for each of a plurality of time steps:
 obtaining, using the weather data, the latitude, and the longitude, a
 sky model that describes a shortwave sky radiance distribution;
 for each surface patch, performing a surface temperature
15 computation operation comprising:
 using the input data and the sky model, computing the
 temperature of the surface patch for the current time step according
 to a time-dependent energy balance equation that comprises a sum
 of separately modelled contributions from a plurality of heat transfer
20 processes;
 after all patches have been processed, re-initialising the temperature
 of each surface patch for the next time step to be the computed surface
 temperature for that surface patch for the current time step; and
 outputting the surface temperature distribution by aggregating the
25 computed surface temperature of each surface patch after the plurality of
 time steps.
2. A computer-implemented method according to claim 1, wherein the heat
transfer processes are shortwave radiation exchange, longwave radiation
30 exchange, convection, and conduction.
3. A computer-implemented method according to claim 2, wherein the
contribution from shortwave radiation exchange and/or the contribution from

longwave radiation exchange is, or are, determined based on Monte Carlo ray-tracing.

4. A computer-implemented method according to claim 3, comprising
5 generating an octree structure based on the input geometrical data; wherein said Monte Carlo ray-tracing is performed in accordance with the octree structure, such that for each ray, only surface patches contained in octree cubes in the path of the ray are used for a ray-patch intersection test.
- 10 5. A computer-implemented method according to claim 1, wherein each surface patch is characterised by multiband material parameters.
6. A computer-implemented method according to claim 5, wherein the multiband material parameters of at least some respective patches are
15 different than the multiband material parameters of the other respective patches.
7. A computer-implemented method according to claim 2, wherein the contribution from shortwave radiation exchange includes a contribution from
20 multiple diffuse scattering.
8. A computer-implemented method according to claim 2, wherein the sky model is the Perez all-weather sky model, and wherein the clearness index of the Perez all-weather sky model is used to infer cloud cover ratio for
25 determining the contribution from longwave radiation exchange.
9. A computer-implemented method according to claim 2, wherein a convection coefficient for determining the contribution from convection is determined by optimized fitting from unshaded surface temperature measurements, or by
30 derivation based on wind speed from the weather data.
10. An apparatus for modelling a surface temperature distribution of a surface of a built environment, the apparatus comprising:
a kernel module that is configured to:
35 obtain input data comprising: a latitude and longitude of the surface;
material parameters for one or more materials of the surface; geometrical

data indicative of a subdivision of the surface into a plurality of surface patches, each surface patch having a surface normal; and weather data;

initialise a temperature of each surface patch; and

for each of a plurality of time steps:

5 obtain, by a sky model component, using the weather data, the latitude, and the longitude, a sky model that describes a shortwave sky radiance distribution;

for each surface patch, perform a surface temperature computation operation comprising:

10 using the input data and the sky model, computing the temperature of the surface patch for the current time step according to a time-dependent energy balance equation that comprises a sum of separately modelled contributions from a plurality of heat transfer processes;

15 after all patches have been processed, re-initialising the temperature of each surface patch for the next time step to be the computed surface temperature for that surface patch for the current time step; and

20 output the surface temperature distribution by aggregating the computed surface temperature of each surface patch after the plurality of time steps.

11. An apparatus according to claim 10, wherein the heat transfer processes are shortwave radiation exchange, longwave radiation exchange, convection, and conduction.

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12. An apparatus according to claim 11, comprising a shortwave component that is configured to determine the contribution from shortwave radiation exchange based on Monte Carlo ray-tracing; and/or a longwave component that is configured to determine the contribution from longwave radiation exchange based on Monte Carlo ray-tracing.

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13. An apparatus according to claim 12, comprising an octree generator that is configured to generate an octree structure based on the input geometrical data; wherein the shortwave component and/or the longwave component is

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configured to perform said Monte Carlo ray-tracing in accordance with the octree structure, such that for each ray, only surface patches contained in octree cubes in the path of the ray are used for a ray-patch intersection test.

- 5 14. An apparatus according to claim 10, wherein each surface patch is characterised by multiband material parameters.
15. An apparatus according to claim 14, wherein the multiband material parameters of at least some respective patches are different than the
10 multiband material parameters of the other respective patches.
16. An apparatus according to claim 11, wherein the contribution from shortwave radiation exchange includes a contribution from multiple diffuse scattering.
- 15 17. An apparatus according to claim 11, wherein the sky model is the Perez all-weather sky model, and wherein the sky model component is configured to use the clearness index of the Perez all-weather sky model to infer cloud cover ratio for determining the contribution from longwave radiation exchange.
- 20 18. An apparatus according to claim 11, comprising a convection component that is configured to determine a convection coefficient by optimized fitting from unshaded surface temperature measurements, or by derivation based on wind speed from the weather data.
- 25 19. A system for modelling a surface temperature distribution of a surface of a built environment, comprising at least one processor in communication with computer-readable storage, the computer-readable storage having stored thereon instructions for causing the at least one processor to perform a
30 method according to claim 1.